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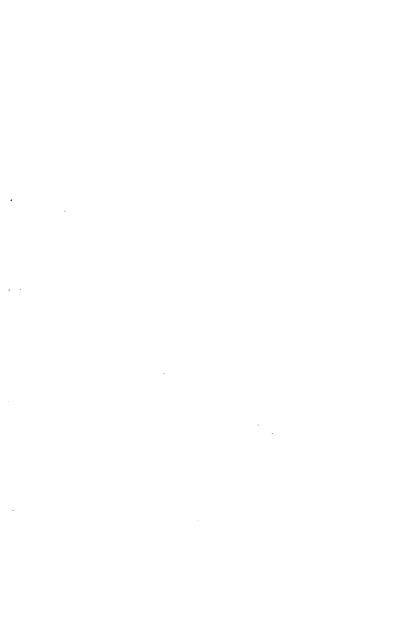
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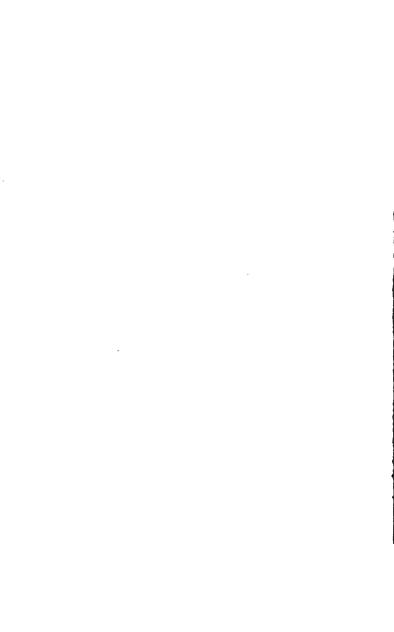


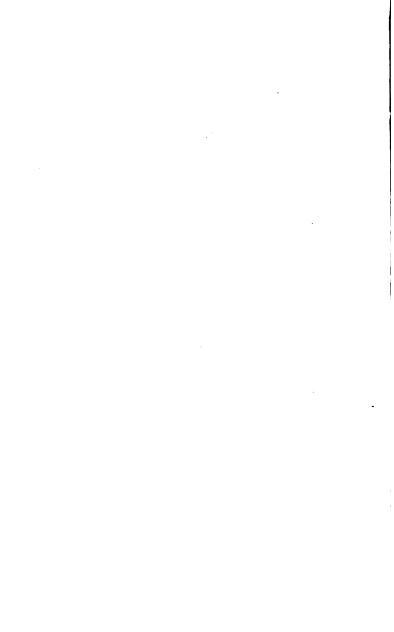


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° HANDBOOK

OF

STREET-RAILROAD LOCATION.

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PROFESSOR OF CIVIL ENGINEERING IN STATE COLLEGE OF KENTUCKY.

FIRST EDITION.

FIRST THOUSAND.

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JOHN P. BROOKS.

PREFACE.

This book is designed to present to the student and engineer that part of the subject of street-railroad construction which is to be performed by the civil, rather than by the electrical engineer. It therefore includes, besides the trigonometrical problems pertaining to railroad curves, the general principles governing the choice of site, grades and curves. It is assumed that every one using the book will be familiar with the practice of land surveying and with the manipulation of surveying instruments, and no space is given to these subjects.

The arrangement is believed to be that which gives the best result in the classroom, while the form and size are convenient for use in the field. Every principle is illustrated by the solution of a numerical example, and at the end of each article several problems are proposed to test the proficiency of the student.

Especial attention is called to the presentation of the subject of compound curves and the use of them as transition curves. The table prepared gives the deflection angles from every chord to every point on the transition curve which is located by rationally increasing radii. It is explained how this table may be applied to main curves of radii between forty and twenty-five hundred feet. A similar table adapted to steam railroads is given by Mr. Godwin in his "Railroad Engineer's Fieldbook."

It is hoped that this book may be instrumental in obtaining for street-railroad construction the same degree of precision and permanence that is found in the best examples of American steam-railway practice.

JOHN P. BROOKS.

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HANDBOOK

OF

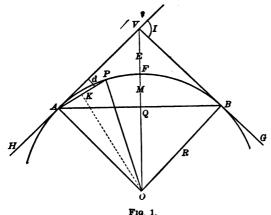
STREET RAILROAD LOCATION.

CHAPTER I.

RAILROAD CURVES.

ART. 1. TRIGONOMETRICAL RELATIONS.

Railroad curves are, in general, arcs of circles, and other forms which are sometimes employed will be considered else-



In Fig. 1, AFB is a curve joining two straight lines or tangents HV and GV, tangent at A and B respectively. The initials of the words Point of Curve and Point of Tangency, P.C. and P.T., indicate the beginning and end of the curve. The lines AV and BV are called Tangent Distances, T. The distance AB is called the Long Chord to distinguish it from any other chord, C, as AP. On the line VO, joining the vertex and the center, VF is the External Distance, E, and FQ the Middle Ordinate, M. The exterior angle at V between the tangents is the Intersection Angle, I, which equals AOB, and the angle between any chord and a tangent at the end of the chord is a Deflection Angle, d.

In Fig. 1, AO is perpendicular to AV, hence

$$AV = AO an AOV$$
,
or $T = R an rac{I}{2}$,
and $R = T \cot rac{I}{2}$.

Let OK be drawn perpendicular to AP, then $VAP = \frac{1}{2}AOP = AOK$, and

 $\sin d = \frac{C}{2B}.$

From Fig. 1,
$$AB = 2T \cos \frac{1}{4}I$$
; $AB = 2R \sin \frac{1}{4}I$; also $AB = 2M \cot \frac{1}{4}I$.

The relation between the length of an arc and its subtended angle is the same as that of a semi-circumference to 180° , hence if L be the length of AFB, $L:AOB = \pi R:180^{\circ}$,

whence
$$L = IR \frac{\pi}{180}$$
, or

$$L = .0174533IR$$

in which I is the angle AOB expressed in degrees and fraction of a degree.

In Fig. 1,
$$QF = OF - OQ$$
, or $R - R \cos \frac{I}{2}$; then
$$M = R\left(1 - \cos \frac{I}{2}\right) = R \text{ vers } \frac{I}{2};$$

$$M=E\cos\frac{I}{2}.$$

In the triangle VFB the angle $VBF = \frac{I}{4}$ and $BVF = \frac{1}{4}(180 - I)$; so

$$VF:VB=\sin VBF:\sin VFB,$$
 or $E=T\tan rac{I}{4}:$ also $E=R\Bigl(rac{1}{\cos rac{I}{2}}-1\Bigr)$ $=R\,\,\mathrm{exsec}\,\,rac{I}{2}$

Many other equations may be formed by solving any of the above for a different factor; for example, let it be required to determine the proper radius for a curve that shall pass 11 feet from the vertex of its tangents, which make an intersection angle 65° 82°. From the next to the last equation,

$$R = \frac{E \cos \frac{I}{2}}{1 - \cos \frac{I}{2}}$$

$$R = \frac{22 \times .84088}{15018} = 58.1 \text{ feet}$$

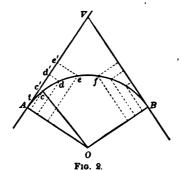
With a table of exsecants at hand the labor of computation is somewhat lessened by using the next formula to that selected.

Prob. 1. In the above example compute the tangent distance, long chord, middle ordinate, and the deflection angle from the tangent to a 10-foot chord.

Prob. 2. Given: E=4 64 feet, M=4 02 feet. Compute R and I.

ART. 2. LOCATING CURVES.

(a) By Offsets from a Tangent.—In Fig. 2 the distance along



the tangent from A to the foot of an offset, as c', and the length of the offset, c'c, are given by

$$Ac'=t=R\sin cOA,$$
 and $cc'=f=1-R\cos cOA;$ or $f=R\,{
m vers}\,cOA.$

Let C be the length of any chord, as Ae, then $f = \frac{C^2}{2R}$.

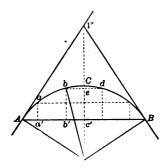
If the angles cod, doe, eof, ... be equal, the arcs subtending them will, of course, be equal, which is a better arrangement than to make Ac', c'd', ... equal. In the field, after c is fixed, Ad' is measured and d is located at the intersection of arcs of radii dd' and dc, with less chance of error than by erecting a perpendicular at d'. For example, let it be required to set stakes 10 feet apart on a curve of 50 feet radius and $I = 88^{\circ}$ 24'.

$$\sin \frac{1}{2}AOC = \frac{5}{R} = .100$$
, and $AOC = 11^{\circ} 29^{\circ}$.
 $t_1 = 50 \times \sin 11^{\circ} 28^{\circ} = 9 \text{ 94 feet}$;
 $t_2 = 50 \times \sin 2 \cdot cOA = 19.48 \text{ feet}$;
 $t_3 = 50 \times \sin 3 \cdot cOA = 28.25$;
 $t_4 = 50 \times \sin 4 \cdot cOA = 35.89$.

The corresponding offsets are 1.0, 8.95, 8.74, and 15.18 feet The number of arcs in the curve is found from 88° $24' \div 11^\circ 28'$ to be 7 +. The points A and B are located by measuring from V the tangent distance $T = R \tan \frac{1}{4}I$, and four arcs of 10 feet chords may be laid off from A and three from B. The remaining chord, $c = 2R \sin \frac{1}{4}(88^\circ 24' - 7 \times 11^\circ 28') = 7.09$ feet, whose measurement affords a test upon the accuracy of the work.

Prob. 3. In the above example compare the length of the curve with that of the eight chords,

(b) By Offsets from a Chord.—In Fig. 3 it is required to



F1G. 3.

locate the curve ACB by offsets from the chord AB. The distance Cc' is first determined by $M = R\left(1 - \cos\frac{I}{2}\right)$. Then any offset, as bb', is c'C - Ce.

$$bb' = c'C - R(1 - \cos COb),$$

or $bb' = c'C - R \text{ vers } COb,$
and $cb' = R \sin COb.$

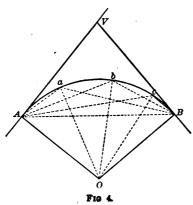
A and B are fixed by measuring the tangent distances from V.

For example: to locate points ten feet apart on a curve when the long chord and radius are given as 58.4 feet and 45 f feet respectively, A and B being fixed. Sin $\frac{1}{2}I = \frac{58 \text{ 4}}{90.0}$ and $I = 80^{\circ}$ 56'. $M = R(1 - \cos 40^{\circ} 28') = 10.76$ feet. The angle subtended by a chord of ten feet will be 12° 46', the distances from the middle of the chord to the offsets from c'A and c'B will be 9.95, 19.40, and 27.89, and the offsets 9.65, 6.36, and 1.08 feet respectively. The small chords at the ends of the curve are found to be $C' = 2R \sin \frac{1}{4}(80^{\circ} \cdot 56' - 6 \times 12^{\circ} \cdot 46') = 1.70$ feet. If it be desired to have the equal chords begin at A, the first arc COb will be 2° 10' and the second 12° 46'; the first arc on the right of the middle will be 10° 36', and the last one 4° 20'. Since the points on the curve are no longer symmetrical with respect to Cc', the offsets and distances along the chord must be computed for each one.

On very flat arcs the middle ordinate is $M = \frac{C^2}{8R}$ without material error.

(c) By Intersection of Two Chords.—If, in Fig. 4, the chord Aa be assumed, the chord aB can be computed by

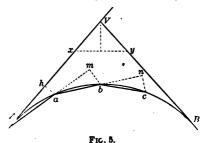
$$aB = 2R \sin \frac{1}{2} (I - AOa).$$



Ab subtends twice the arc AOa and bOB = I - 2AOa. The chords from each point to A and to B may thus be computed and any point, as b, located by intersecting a small arc of radius

Ab by one of radius Bb. This is done by first determining within a foot or so where the point will fall and driving temporary stakes, one inside and one outside the curve, about two feet apart, into which nails are driven on an arc of radius Ab. and a string is stretched between them. The divergence of this chord from its arc will be inappreciable, and the point on the string and the arc of radius bB will be directly over b. This is not a good method of locating curves unless each of the chords is 1 ss than the length of the tape; it may, however, be applied to longer curves by first locating the middle of the curve by measuring the external distance from V toward O and locating the intermediate points in the manner described above. For example, let $I = 96^{\circ} 42'$ and R = 60 feet. E will be 30.28 feet, and the chord of $\frac{I}{2}$ equals 49.14 feet, so the middle point of the curve may be found at the intersection of arcs of these radii from V and A respectively as centers. points 10 feet from A and from B will be 39.84 feet from the middle, those 10 feet from the last will be 30.27 feet from the middle, and so on.

(d) By Offsets from a Chord produced.—The angle mab, Fig. 5, between a chord and the previous chord produced is the



same as that at the center subtended by the chord, and the angle between the tangent and the first chord VAa is one half this amount, or. if bam = d,

$$\sin \frac{1}{2}d = \frac{C}{2R};$$

$$mb = C \sin d$$
,
 $ma = C \cos d$.

The length of the last chord, c', ending at B will subtend an angle at the center of I-nd, when n is the number of chords laid off from A.

$$C' = 2R \sin \frac{1}{2}(I - nd).$$

This is an effective method of setting the stakes on a curve without the aid of an instrument. The intersection angle, if unknown, may be approximately determined by laying off Va = Vy on VA and VB and measuring xy; then

$$\cos\frac{I}{2} = \frac{xy}{2 Vx}.$$

The points A, B and a are fixed as described before. The ring at the end of the tape is hooked over the nail in stake A, and C + am is measured on Aa produced, locating m. The ring is then hooked at a, and the mark C + mb held at m; the division on the tape indicating a chord distance from a will be over b when both s ctions of the tape are drawn taut

For instance, let Vz=50 feet, xy=72.02 feet, and R=45 feet, to set stakes 10 feet apart on the curve. $\cos \frac{1}{2}I=.7202$, $I=92^{\circ}$ 08. I=46.71 feet. $\sin \frac{1}{2}d=.1111$, $d=12^{\circ}$ 46. The last chord will subtend an angle of 92 08 -7 (12° 46') or 2° 46' and be equal to 2.17 feet. The chord produced will be $am=10\cos 12^{\circ}$ 46' =9.75 feet, and $mb=10\sin 12^{\circ}$ 46' =2.21 feet.

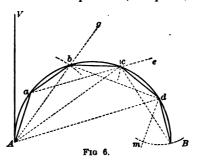
(e) By Chords and Deflection Angles.—If the chords in Fig. 6 be all equal, they will subtend angles at A, each equal to VAa or d, when 2d is the angle at the center of the curve subtended by the same chord. The angle at any point on the curve, as b, between a chord from A produced, and the chord bd from b to any other point on the curve, is the same as the angle at A between the tangent and Ad;

or
$$gbd = VAd$$
,
also $ecd = VAc$ or aAd .

With the instrument at A the first chord Aa is measured

making an angle d with AV. The angle VAg is next deflected from the tangent, and with the end of the tape at a, the mark indicating the length of chord is moved through a small arc till it comes into the line of sight, when the point b is located. If the transitman be unable to read the graduation, on the tape, a pencil may be held vertically on the proper division, and he will order it moved to the right or left till it is bisected by the line of sight.

After several points have been located from A in the manner described above, the chords between them become nearer and nearer perpendicular to those from A, and hence successive points are fixed with less precision than those nearer A. In Fig. 6, if the end of the tape be at d, the pencil, held on the



proper division in swinging through the arc of radius dB will move with reference to AB nearly as the sine of AdB varies. If this angle be near 90°, a small movement along the small arc could not be detected by the transitman, and in an extreme case B might even be located at m. The proper method is to move the instrument to a point on the curve whose deflection angle from the tangent is about 45° and to locate the remaining points from there.

Before beginning the work of running the curve the defiection angle for each chord and the total deflection from the tangent to each point are computed and tabulated as shown below. When the instrument is moved from A to some station as b, the back-sight is taken to any of the points already fixed preferably a distant one, with the vernier set at the deflecti

from the tangent to the chord from A to that point, so that the vernier will always read zero when the telescope is pointed to A. The line of sight is turned through 180° , either in azimuth or by revolving the telescope on its axis, and the veriner readings for all the following points are given in the column of total deflections in the following field-notes for the curve in Fig. 6:

Station.	Distance.	Ohord Deflection.	Total Deflection.
A a b c d B	0 0 0 0 0 0 0 0 0 0 0 0 0 0	0° (0' d d d d d	0° 00' d 2d 3d 4d <u>1</u> I

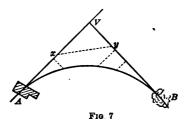
If the instrument be at c and a back-sight is taken to A, the vernier reading is zero; if to a or b, readings taken from the notes are d or 2d. The telescope is turned through 180° and the notes indicate that 4d is the proper setting for locating the point d. The last deflection is $\frac{1}{2}I - 4d$, and the measured and computed lengths of dB should agree.

As an example let it be required to make a table of field-notes for a curve whose radius is 50 feet and intersection angle 106° 18'. Then T=66.72 feet. The deflection for a chord of 10 feet is $\sin d=5+50=.10000$, $d=5^{\circ}$ 44'. The length of the curve is 92.75 feet, so the last chord will subtend an angle of 106-18' less 9 times 11° 28', or $d'=1^{\circ}$ 38' and C'=2.71 feet.

Station.	Distance.	Chord Deflection.	Total Deflection.	Remarks.
P. C. a b c d e f g h	0 feet 10 10 10 10 10 10 10 10 10 10 2.71	0° 00′ 5 44 5 44 5 44 5 44 5 44 5 44 5 44 1 33	0° 00′ 5 44 11 28 17 12 × 22 56 28 40 34 24 40 08 × 45 52 51 36 53 09	c Transit Point . g Transit Point

With the transit at g, to take a back-sight on c the vernier should be set at 17° 12′, the total deflection for c. The readings for h, i, and P T. are the values in the fourth column opposite those stations.

When the intersection point or points of curve or tangency are not situated so that they may be occupied by the instrument, the curve may still be located by one of the foregoing methods. If any line, as xy, Fig. 7, be run from a point on



one tangent to a point on the other, the sum of Vxy and Vyx will be the intersection angle. In the triangle Vxy, Vx and Vy may be computed when the angles and the length of xy are known: then the radius having been assumed, AV is computed and hence xA is known. Offsets to the tangent may be computed for assumed distances from A and B.

Prob. 4. Given $I=85^{\circ}\,26'$ and E=21.66 feet. Compute offsets and distances along the long chord for points 10 feet apart on the curve.

Prob. 5. If a chord c subtends an arc d, compute c_2 , c_4 , and c_4 for arcs 2d, 3d, 4d, and 5d.

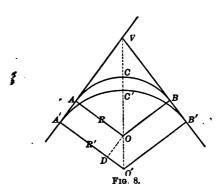
Prob. 6. Given: Vx = 25 feet, xy = 33.5 feet, and E = 26.0 feet. Make the computations necessary in laying out the curve in eight equal chords (Fig. 5).

Prob. 7. Make table of deflection angles when $I = 106^{\circ} 18'$ and R = 80 feet, and compute the difference between the length of the curve and that of the sum of the chords.

Prob 8. With the transit at P. C. when R=80 feet and $I=150^{\circ}$, how far could a point near the P. T. on a radius of 5 feet and center at the point next to the P. T., be m ved without departing more than 0.01 feet from the ch rd P. C. -P. T.?

ART. 3. CHANGING THE RADIUS.

(a) To change the Radius to agree with a given change in the Tangent.—In Fig. 8, AO is the radius of the curve AB



whose tangent is AV; it is required to find the change in the length of the radius that A may be moved to A'. In the triangle OO'D, O'D = OD cot OO'D, or

$$R'-R=(T'-T')\cot\frac{I}{2}.$$

The new radius will be greater or less than the first according as VA' is greater or less than VA.

(b) To change the Radius to effect a given change in the External Distance.—It is required to determine a radius that shall cause the curve to pass through C' instead of through C' in Fig. 8. The distance $VC = R \div \cos \frac{I}{2} - R$,

and
$$VC' = R' \div \cos \frac{I}{2} - R'$$
, then $R' - R = \frac{VC' - VC}{\sec \frac{I}{2} - 1}$, or $R' - R = CC' \operatorname{exsec} \frac{I}{2}$.

If CC' be measured, the difference in radii is found numerically.

(c) To change the Radius so that from the same P. C. the curve shall end in a parallel tangent at a given distance from the original one.—In Fig. 9, V'B' is parallel to VB, and the required change of radius is OO'. If BD be parallel to OO', B'D and BD are each equal to OO', and B and B' are on the arc of a circle of radius R' - R and center D;

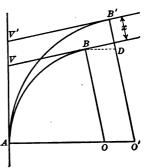


Fig. 9.

then
$$(R'-R)=rac{x}{\mathrm{vers}\ I},$$
 or $(R'-R)=rac{x}{2\sin^2\frac{I}{2}}.$

in which x is the distance between the two positions of the tangent. The formula is equally applicable when second tangent is inside the first.

(d) To change the Radius so that the curve shall end in a parallel tangent directly opposite the original P. T. and a given distance from it.—In Fig. 10 the change in length of the tangents is DV', or

$$(T'-T)=DV'.$$
 $(R'-R) anrac{I}{2}=x\cot I;$ then $R'-R=x\cot I\cotrac{I}{2},$ also $R'-R=rac{x}{\mathrm{exsec}\ I}.$

The new curve will begin at A', and when R' - R or O'G is known AA' may be computed.

$$AA' = (R' - R) an I,$$
 also $AA' = x \cot rac{I}{2}.$

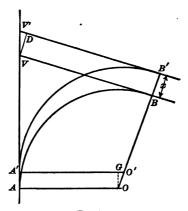


Fig. 10.

The method of computation is the same whether the new tangent is outside or inside the original one.

(e) To change the Radius to agree with a given change in *I*. 1st. When P. C. remains unchanged.

In Fig. 11 the change in I is BVB'' and, if the P.C. remains at A, OO'' is the required change of radius. Since AV is common to both curves,

$$R' \tan \frac{AO''B''}{2} = R \tan \frac{AOB}{2};$$

$$R' = R \tan \frac{I}{2} \cot \frac{I'}{2},$$

in which R' is the only unknown quantity, since $I' = I \pm$ the given change BVB''.

2d. When the P. T. remains unchanged.

Under this condition the vertex is moved from V to V' and

the given change of I is VBV' in Fig. 11. Since B is fixed, its distance from AV is

$$R'-R'\cos I'=R-R\cos I,$$

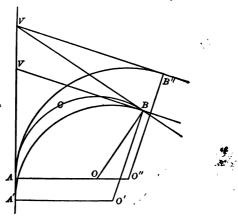


Fig. 11.

in which the algebraic sign of cosine I' and of cosine I must be observed.

or
$$R' = R(1 - \cos I) \div (1 - \cos I'),$$
 also $R' = R \frac{\text{vers } I}{\text{vers } I'}.$

Since A'O' is parallel to AO, the distance from B to each is

$$R' \sin I' = R \sin I,$$

 $AA' = R' \sin I' - R \sin I,$

which determines the position of the new P. C.

OF

For example, let R=60 feet and $I=106^{\circ}$ 80'; it is required to determine the radius and P. C. of a curve that end at the same P. T. making $I'=110^{\circ}$.

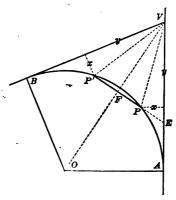
$$R' = 60(1 - \cos 106^{\circ} 30') \div (1 - \cos 110^{\circ}),$$

 $R = 57.4$ feet.

 $AA' = 57.4 \sin 110^{\circ} 00' - 60 \sin 106^{\circ} 30' = 8.60 \text{ feet.}$

The new P. C. will be on AV. 360 feet from A.

(f) To find the radius of a curve which shall pass through a given point and connect two given tangents.—Let VA and VB in Fig. 12 be the given tangents, and P the given point lo-



Frg. 12.

cated by an offset x from VA distant y from the vertex. If a point P' be located from VB with the coordinates x and y, the required curve will pass through it and PP' will be perpendicular to the line bisecting AVB. Then tan AVP = x + y, and $PVF = \frac{1}{2}(180 - I) - AVP$; hence PVF may be computed. $PV = \sqrt{x^2 + y^2}$, and therefore PF and VF' may be found; also in the right triangle EVF, $VE = VF \div \sin \frac{I}{2}$.

and FE = VF cot $\frac{I}{2}$; from which the numerical values of FE and VE may be determined. Then

$$EA = \sqrt{P'E \times PE}$$

and VA = VE + EA, which is the tangent of the required curve whose P. C. is at A. The radius may then be computed, $R = VA \cot \frac{I}{2}$. If the tangents are located, P'P and PE may be measured instead of being computed.

For example let, $I = 120^{\circ}$, y = 80 feet, and x = 20 feet, to de-

termine T and R. Here $\tan AVP = .250$, $AVP = 14^{\circ} 02'$, and $PVF = 15^{\circ} 58'$. $PV = \sqrt{400 + 6400} = 82.46$ feet. PF = 82.46 sin 15° 58' = 22.69 feet. VF = 82.46 cos 15° 58' = 79.28 feet. $VE = 79.28 \div .8660 = 91.54$ feet. Then

$$EA = \sqrt{28.09 \times 68.47} = 39.76$$
 feet, $T = 131.30$, and $R = 131.86 \times .5774 = 75.8$ feet.

Prob. 9. Given: $I=75^{\circ}$ 32', R=50 feet. It is required to find the radius of a curve that shall connect the same tangents and pass 2 feet farther from the vertex.

Prob. 10. In Fig. 12 let x = 15 feet, y = 65 feet, and $I = 96^{\circ}$. Find the radius.

Prob. 11. Given: $I=87^{\circ}$ 20' and R=60 feet. What is the radius of a curve that will connect the same P. C. with a parallel tangent 4 feet outside that through the original P. T.? What will be the new tangent distances?

Prob. 12. If, in the above problem, the second P. T. be opposite the first, compute the new radius and the necessary change in position of P. C.

Prob. 13. Given: $I = 100^{\circ}$, $I' = 105^{\circ}$, and R = 65 feet. Compute the length of the new curves when P. T. is changed and when V is changed.

ART. 4. SHIFTING THE CURVE.

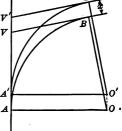
(a) To move the Point of Curve along the tangent so that the curve may end in a tangent parallel to the original one and at a certain distance from it.—Let x in Fig. V

13 be the distance between the two V

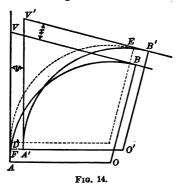
tangents, then

$$VV' = AA' = x \div \sin I$$
, because $A'O'B' = AOB$, since AB is moved bodily without change of dimensions to $A'B'$.

(b) To move the curve so that both
the Points of Curve and of Tangency may be on tangents parallel to the former ones and
at given distances from them.—In Fig. 14 the curve AB may



be transferred to A'B' by first moving A along AV till B is on VB'; the curve will then be shown by the dotted line DE, and E may be moved along V'B' till D is in V'A', when A'B'



will be the required curve. Then F is the point on AV opposite A', and

$$AF = \frac{x + y \cos I}{\sin I},$$

in which x is positive when tangent through P. T. is moved out, y is positive when tangent through P. C. is moved in, and $\cos I$ is negative when I is greater than 90°. When the tangents are moved in opposite directions, the distances x and y are negative, and when AF is found to be negative it means that F is on VA produced.

For example, in Fig. 14 let it be required to transfer the curve AB to A'B' when y=3 feet, x=4.2 feet, $I=95^{\circ}$ 22', and R=50 feet. In this case x is positive, y is positive, and $\cos I$ is negative; therefore

$$AF = \frac{4.2 - 3 \times .0935}{.9956},$$

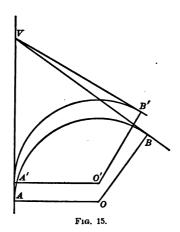
$$AF = 3.94$$
 feet,

and A' is located by measuring forward 3.94 feet and erecting a perpendicular offset of 3 feet at F.

If, in the above example, the tangent through the P. T. were

moved in, x would be negative and $AF = \frac{-4.2 - 3 \times .0935}{.9956}$ = -4.50 feet; hence F would be on VA produced.

(c) To move the curve to agree with a given change in direction of the tangent through the P. T.—In Fig. 15 let BVB'



be the given change in I, V remaining fixed; then

$$VA = R \tan \frac{1}{2}$$

$$VA' = R \tan \frac{I}{2}$$
;

$$AA' = R\left(\tan\frac{I}{2} - \tan\frac{I'}{2}\right).$$

If AA' becomes negative from the above equation, A' is on VA produced.

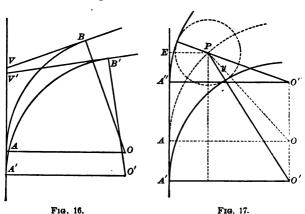
When the given change in direction is from a different vertex, as shown in Fig. 16.—The change in the position of the P. C. due to the change in I is, as above, $R\left(\tan\frac{I}{2}-\tan\frac{I'}{2}\right)$, and

any change in the position of the vertex will cause an equal change at the P. C.; hence

$$AA' = R\left(\tan\frac{I}{2} - \tan\frac{I'}{2}\right) + VV',$$

in which the proper algebraic signs must be observed.

For example, let R=60 feet, $I=80^{\circ}$, $I'=114^{\circ}$, and VV'=6 feet from V toward A. Here AA'=60 (0.88910 -1.58986) -6.0=-48.05 feet, and hence the curve will begin 48.05 feet from A on VA produced.



(d) To locate the P. C. of a curve of given radius which shall pass through a point at a given distance from the tangent.—In Fig. 17 let P be the point, distant x from AE, through which it is required to pass the curve of radius R. Then

$$\cos 2EAP = (R - x) + R,$$
 and
$$EA = x \cot EAP,$$

which gives the location of the point of curve.

(e) To locate the P. C. of a curve that shall pass at a given distance from a point whose distance from the tangent is known.—In Fig. 17 let it be required to locate a curve tangent $\triangle AE$ that shall be a distance y from P which is x from AE.

If a circle of radius y be drawn with a center at P, it will be tangent to the required curve; therefore

and
$$EA' = (R - x) + (R + y),$$

$$EA' = (R + y) \sin A'O'P,$$

$$\overline{EA}^2 = (R + y)^2 - (R - x)^2,$$

which is sufficient to fix the point of curve.

The given distance y may be between P and the tangent, in which case

$$\cos A''O''P = (R-x) \div (R-y),$$
 and
$$EA'' = (R-y)\sin A''O''P.$$

It is evident that y cannot be greater than x unless the curve is in the opposite direction.

For example, let the line midway between the rails be 18 feet from the curb, to locate the P. C. of a curve of 45 feet radius that shall pass 11 feet from a given curb corner. The curb corner is represented by P in Fig. 17; then $\cos A''O''P = (45 - 13) + (45 - 34)$, or $A''O''P = 37^{\circ}$ 26'. Then $EA'' = 34 \sin 37^{\circ}$ 26' = 20.67 feet.

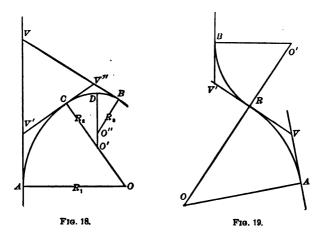
Prob. 14. The middle line of a railroad-track is to be 20 feet from the curb; a curve is to begin opposite a point on the curb 22 feet from the curb corner, which is to be 12.8 feet from the middle line of the curve. Find the radius.

Prob. 15. The middle line of a track is 18 feet from the curb; a curve of 50 feet radius, away from the curb, is to pass 30 feet from a given point on the curb. Find the length of a chord from the P. C. to the part of the curve nearest the given point.

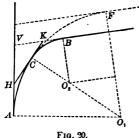
ART. 5. COMPOUND CURVES.

The curve ACB, Fig. 18, is called compound from the fact that it is a combination of curves of different radii, as AO, CO', and DO''. The points C and D are designated Points of Compound Curvative, P. C. C. The sum of the angles AOC,

CO'D, and DO''B equals the deflection angle at V and the tangent distances VA and VB are of unequal lengths,



In Fig. 19 the center of the second curve is on the radius of the first produced, and the curves are in opposite directions. Such a condition is a special case of compound curves which is



O₁ (a) To locate a compound curve between two given tangents when

termed Reverse Curve. The place where the radius AO changes to RO' is called the Point of Reverse Curvature, P. R. C. The radii OA and O'R may or may not be of equal length, and the difference

between the central angles, O and O', is that between AV and BV'.

the radii, I, and one tangent are known.

1st. When the distance from the vertex to the P. C. of the flatter curve is given.—In Fig. 20 it is required to locate a compound curve beginning at A, distant T_1 from V, and ending on VB with radii $AO_1 = R_1$ and $CO_2 = R_2$.

If AC be produced to F, making $AO_1F = I$, then

$$(R_1 \tan \frac{1}{2}I - T_1) \sin I + R_2 + (R_1 - R_2) \cos O_2 = R_1;$$

$$\cos O_2 = 1 - \frac{(R \tan \frac{1}{2}I - T_1)}{R_1 - R_2} \sin I;$$
so
$$\cos O_2 = \frac{T_1 \sin I + R_1 \cos I - R_2}{R_1 - R_2},$$

in which the algebraic sign of $\cos I$ must be observed. If T be larger than R_1 tan $\frac{1}{2}I$, the problem is incapable of solution.

In the triangle VHK, $HK = R_1 \tan \frac{1}{2}O_1 + R_2 \tan \frac{1}{2}O_2$;

then
$$VK = HK \frac{\sin O_1}{\sin I}$$
, and $VB = VK + R_2 \tan \frac{1}{2}O_2$; otherwise $T_2 = VB = \frac{R_1 - (R_1 - R_2)\cos O_1}{\sin I} - R_2 \cot I$,

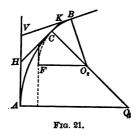
which determines the location of B.

2d. When the distance T_2 from the vertex to the P. C. of the sharper curve is known.—In Fig. 21, BC is produced to F, making $BO_2F=I$.

$$T_2 \sin I + R_2 \cos I + (R_1 - R_2) \cos O_2 = R;$$

 $\cos O_1 = \frac{R_1 - T_2 \sin I - R_2 \cos I}{R_2 - R_1}.$

When I is more than 90° the cosine of I is negative.



The tangent $VA = T_1$ is found as in the first case.

also

$$VA = VH + R_1 \tan \frac{1}{2}O_1,$$

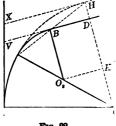
$$T_1 = \frac{R_1(\cos O_2 - \cos I) + R_2(1 - \cos O_2)}{\sin I}.$$

For example, let $T_2 = 26.2$ feet, $I = 60^{\circ}$, $R_2 = 40$ feet, and $R_1 = 60$ feet; to locate the P. T. and the P. C. C. $60 - 26.2 \times .86603 - 40 \times .5 = .868$ and $R_1 = .80^{\circ}$.

$$\cos O_1 = \frac{60 - 26.2 \times .86603 - 40 \times .5}{20} = .866$$
, and $O_1 = 30^\circ$; $O_2 = I - O_1 = 30^\circ$; $T_1 = \frac{60 \times .366 + 40 \times .134}{.866} = 31.5$ feet.

The P. C. C. may be located from either end of the curve after T_1 has been computed. The chord $BC = 2R_2 \sin \frac{O_2}{2} = 103.5$ feet.

(b) To locate a compound curve between two given tangents when I, T_1 , T_2 , and one radius are given.



1st. When the larger radius is known.—In Fig. 22 let the arc of radius R_1 be continued until it ends in a tangent parallel to VD; then

$$HX = T = R_1 \tan \frac{I}{2}.$$

F1g. 22.

Then $HBD = VBC = \frac{O_2}{2}$, and in

the triangle HBD

$$\cot \frac{O_2}{2} = \frac{BD}{HD},$$
or
$$\cot \frac{O_2}{2} = \frac{T - T_2 + (T - T_1)\cos I}{(T - T_1)\sin I},$$

in which $T_1 = VA$ and $T_2 = VB$.

Also from the same figure $R_2 = R_1 - HD - KO_1$,

or
$$R_2 = R_1 - (T - T_1) \frac{\sin I}{1 - \cos O_2}$$

For example, let $I = 61^{\circ}$ 56', $R_1 = 80$ feet, $T_1 = 38$ feet, and $T_2 = 28$ feet. Then $T = 80 \times .60007 = 48.0$ feet; cot $\frac{O_2}{2} = \frac{20 + 10 \times .7405}{10 \times .8824} = 2.7998$, or $O_2 = 39^{\circ}$ 18'; $R_2 = 80^{\circ}$

$$-10\frac{.88240}{.22616} = 41.0$$
 feet.

2d. When the smaller radius is known.—Let the curve of smaller radius be extended to a tangent parallel to T_1 . Then, as before,

$$\cot \frac{O_1}{2} = \frac{AD}{H\overline{D}}$$

$$= \frac{T_1 - T + (T_2 - T) \cos I}{(T_2 - T) \sin I},$$

in which T, T_1 , and T_2 represent HX, AV, and BV in Fig. 23.

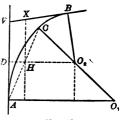


Fig. 28.

Also
$$R_1 = R_2 + AD + (R_1 - R_2) \cos \theta_1$$
,
 $R_1 = R_2 + (T_2 - T) \frac{\sin I}{1 - \cos \theta_1}$,

in which R_2 must always be selected smaller than T_2 cot $\frac{I}{2}$, else the curve will become reverse.

For example, let $I = 119^{\circ}$ 04', $T_1 = 120$ feet, $T_2 = 100$ feet, and $R_2 = 40$ feet. Then $T = 40 \times 1.69992 = 68$ feet. Since I is greater than 90° its cosine is negative, and

$$\cot \frac{O_1}{2} = \frac{120 - 68 - 32 \times .48583}{32 \times .87406},$$

or
$$O_1 = 75^{\circ} 00'$$
. $R_1 = 40 + 32 \times \frac{87406}{74 \cdot 118} = 77.7$ feet.

(c) To connect a given curve with a given tangent by another curve of given radius.—This is a case in which the distance between the given tangent and that to the given curve parallel to the first is known, as DH in Fig. 24, but the angle O_1 is to be determined. In Fig. 24 let AC be the given curve of radius R_1 , and BV the given tan-

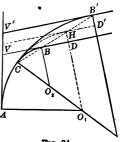


Fig. 24.

gent, making the angle I with AV. If AC be produced to H, making $HO_1A = I$, HD = d, and if R_2 be assumed,

$$d = \left(R_1 \tan \frac{I}{2} - AV\right) \sin I;$$

$$\cos O_2 = 1 - \frac{d}{R_1 - R_2}.$$

The point B is located by laying off from V the distance T_3 as computed in (a) above.

If the required tangent is to be outside of H, as V'B', the above formula becomes

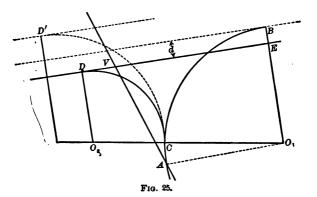
$$\cos O_2 = 1 - \frac{d}{R_2 - R_1}.$$

The P. C. C. is found by running a tangent at any point on the original curve, as A, to intersect the given tangent; the angle I is then measured, and $O_1 = I - O_2$. The chord AC then is

$$AC=2R_1\sin\frac{O_1}{2},$$

which gives the location of P. C. C.

2d. When the required curve is to be in the opposite direction from the first.—Let AB, Fig. 25, represent the curve to



be connected with the tangent DE. From any point, as A, on the curve AB a tangent is run to intersect the line DE, and the intersection angle AO_1B is measured, B in the figure be-

ing the point where the tangent to ACB is parallel to DE. Then O_2O_1B is found from

$$\cos O_3 O_1 B = \frac{R_1 - R_2 - d}{R_1 + R_2},$$

$$AO_1 C = I - O_2 O_1 B.$$

from which the distance to C from the selected point may be computed. The curve CD may then be located by any of the usual methods, the total deflection from a tangent at C to the

and

point D being $\frac{1}{2}(180^{\circ} - O_1)$. When the required tangent is outside of the tangent through B, the formula is

$$\cos CO_1B = \frac{R_1 - R_2 + d}{R_1 + R_2}$$
, .

and the P. R. C. may be fixed by measuring the computed chord AC with a deflection $\frac{1}{4}(I-O_1)$ from the tangent at A.

For example, let it be required to connect a given curve ACB of radius 50 feet, Fig. 25, with the tangent D'E' by a curve of radius 100 feet. From any convenient point on BCA, as A, a tangent is produced to intersect D'E' at V, I is found to be 117° 32′, and AV = 115.4 feet. From which

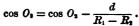
$$d = (115.7 - 50 \tan 58^{\circ} 46') \sin I = 29.5 \text{ feet.}$$

Then
$$\cos O_1 = \frac{50 - 100 + 29.5}{100 + 50} = -.13666$$
, or $O_1 = 97^{\circ}$ 51', and $AO_1C = 19^{\circ}$ 41'; hence $AC = 2 \times 50 \times .1709 = 17.09$ feet, and $VAC = 9^{\circ}$ 50', giving the location of the P. C. C., from which the curve may be run by deflection angles from a tangent at C . The deflection for D' will be $\frac{1}{2}(180^{\circ} - 97^{\circ}) 51' = 41^{\circ}) 04'$.

(d) To change the position of the P. C. C. so that the curve may end in a parallel tangent a given distance from the first.

1st. When the P. C. of flatter curve is fixed.—In Fig. 26 let ACB be the given compound curve; it is required to change the position of C so that the curve may end at B_1 in a tangent parallel to that at B_1 , and d feet inside of it. Let the curve AC be produced to H_1 , making $AO_1H = I$. Then, since the locus

of the intersections of the radii is a circle of radius $R_1 - R_2$ and center at O_1 , from the figure



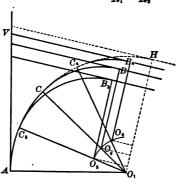


Fig. 26.

If the curve were to be moved outward the same distance to B_4 , then

$$\cos O_4 = \cos O_2 + \frac{d}{R_1 - R_2},$$

and the new P. C. C. is located from A, since $AO_1C_4 = I - O_4$.

2d. When the P. C. of the sharper curve is fixed,—In Fig. 27, ACB is the given compound curve ending at B; it is required to change the position of C so that the curve may end in B_1 , d feet inside the tangent through B. Let the curve AC be produced to H, making $HO_1A = I$; then

$$\cos O_{2} = \cos O_{2} + \frac{d}{R_{2} - R_{1}}.$$

$$\cos O_{4} = \cos O_{2} - \frac{d}{R_{2} - R_{1}}$$

when the required tangent is outside that through B.

For example, let $R_1 = 60$ feet, $R_2 = 40$ feet, $O_1 = 25^{\circ}$, and $O_2 = 97^{\circ}$ 52'; it is required to so change the P. C. C. that the tangent at the end of the sharper curve may be moved out 5 feet. Then $\cos O_4 = -.13687 + \frac{5}{30}$, or $O_4 = 83^{\circ}$ 30' and

 $O_1 = 39^\circ$ 22'. The chord from the P. C. to the P. C. C. is $2 \times 60 \times .3368 = 40.42$ feet.

Prob. 16. Given: $R_1 = 40$ feet, $R_2 = 80$ feet, $O_1 = 30^{\circ}$, and $O_2 = 42^{\circ} 30'$. Find the chord from the P. C. to the P. C. C. so that the compound curve shall end in a parallel tangent 4 feet inside the present one.

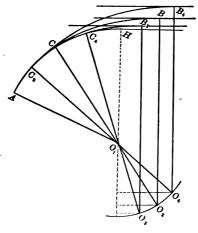


Fig. 27.

Prob. 17. In the last problem compute maximum values for +d and -d.

. Problem 18. Given: $R_1 = 55$ feet, $R_2 = 43$ feet, $I = 64^\circ$, and $I_1 = 33$ feet. Find the value of I_2 and the position of the P. C. C.

Prob. 19. Compute maximum and minimum valus for the assumed T_1 .

Prob. 20. Given: $I = 76^{\circ}$, $T_1 = 40$ feet, $T_2 = 30$ feet, and $R_1 = 75$ feet. Make the computations necessary to locate the compound curve.

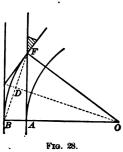
Prob. 21. It is required to connect a curve to the right, of 50 feet radius, with a line which makes an angle of 75° with a tangent to the given curve 65 feet from the point of tangency, by a curve to the left of 40 feet radius.

CHAPTER IL

TURNOUTS AND SIDINGS.

ART. 6. TURNOUTS FROM STRAIGHT TRACK.

The part of the track which is common to the outside rail of the turnout and the inner rail of the main track is called the



Frog, as shown by the small shaded triangle at F in Fig. 28. The distance AF is the Frog Distance, the length of the frog divided by its breadth is the Number of Frog, as $\frac{cd}{ab}$ in Fig. 29, and the Frog Angle, F, is the angle acb or that between the tangent to the outer rail of the turnout and the main track, being

the same as AOF in Fig. 28. The

Fig. 30.

Radius of the Turnout is $AO + \frac{1}{4}G$, when G is the gauge of the track or the distance between the d rails. The Standard Gauge is 4' 81". The Switch, Fig. 30, is the arrangement at A, Fig. 28, by which a car is

deflected from the straight track to the curve.

In the triangle AFO, Fig. 28. the Frog Distance AF is

$$AF = \sqrt{2GR}$$

also from ABF AF = 2GN

Since
$$2N = \cot \frac{F}{2} = \cot BFA$$
,

then
$$R = 2GN^2 = \frac{1}{2}G \cot^2 \frac{F}{2}$$
,

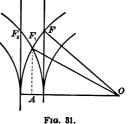
by combining the two values of AF;

also
$$\cos F = \frac{2R - G}{2R + G}$$
.

(a) When Two Turnouts of the same radius in Opposite Directions begin at the Same Point.—As shown in Fig. 31, the

number, N_1 , of the frog at the intersection of the curves may be stated in terms of that on the straight rail, for in the triangle AOF_1

$$egin{aligned} \overline{AF_1^2} &= G\Big(R + rac{G}{4}\Big), \ AF_1 &= R an rac{1}{8}F_1, \ AF_1 &= rac{R}{2F_1}; \end{aligned}$$



hence $N_1 = \sqrt{\frac{4N^4}{2N^2+1}}$

also

in which N_1 is the number of frog at F_1 and N is the number of that at F.

The switch for a case like Fig. 31 must be so designed that a car may be made to take either of three directions, and for this reason it is called a Three throw Switch.

(b) When the Radii of the Turnouts are Unequal.—In the

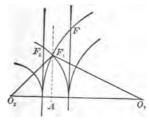


Fig. 32.

triangle $O_1O_2F_1$, Fig 32,

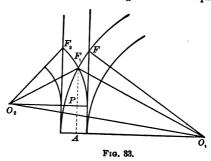
$$\tan \frac{1}{2}O_2 = \sqrt{\frac{R_1G}{R_2(2R_1 + 2R_2 + G)}}$$

and
$$an rac{1}{2}O_2F_1O_1 = \sqrt{rac{4R_1R_2}{G(2R_1 + 2R_2 + G)}};$$
 the frog angle $F_1 = 180^\circ - O_2F_1O_1,$ and $N_1 = rac{1}{2}\cot rac{1}{2}F_1,$ $AF_1 = \left(R_2 + rac{G}{2}\right)\sin O_2,$ $O_2A = \left(R_2 + rac{G}{2}\right)\cos O_2,$

from which the location of the frog F_1 is established.

For example, let $R_1 = 50$, $R_2 = 40$, and the gauge be the standard; then $\tan \frac{1}{2}O_2 = \sqrt{\frac{235.4}{40(100 + 80 + 4.708)}}$ or $O_2 = 20^\circ$ 14'; $\tan \frac{1}{2}O_2F_1O_1 = \sqrt{\frac{4.40.50}{4.708(100 + 80 + 4.708)}}$, or $O_1F_1O_2 = 143^\circ$ 32', so $F_1 = 36^\circ$ 28' and $N_1 = \frac{1}{2}$ cot 18° 14' = 1.52; $AF' = 42.35 \times .84584 = 14.65$ feet; $O_2A = 42.35 \times .9383 = 39.74$ feet, and the point of the frog F_1 is 14.65 feet from the point of curve and 0.26 feet from the middle line of the track.

(c) When the Opposite Turnouts begin at Different Points.—A case of this kind is shown in Fig. 33. It is required to de-



termine the frog angle F_1 and the frog distance AF_1 when AP, or a, and either the frog angles F_2 and F or the radii of the turnouts are known. When F_2 and F are given,

$$R_1 = rac{G}{2} \cot^2 rac{F}{2};$$
 $O_1O_2 = \sqrt{(R_1 + R_2)^2 + a^2}.$

Then in the triangle $O_1F_1O_2$ all the sides are known, and

$$\cos O_1 = \frac{\overline{O_1 F_1^2} + \overline{O_1 O_2}^2 - \overline{O_2} F_1^2}{2O_1 O_2 \cdot O_1 F_1},$$
also
$$\cos O_2 = \frac{\overline{O_2 F_1}^2 + \overline{O_1 O_2}^2 - \overline{O_1 F_1}^2}{2O_1 O_2 \cdot O_2 F_1};$$
then
$$F_1 = O_1 + O_2,$$

$$\tan O_2 O_1 A = \frac{a}{R_1 + R_2},$$
and
$$AF_1 = \left(R_1 + \frac{G}{2}\right) \sin F_1 O_1 A.$$

The above expressions are readily solved when numerical values are substituted, but a formula giving AF_1 in terms of R_1 , R_2 , and a directly is unwieldy.

(d) When the three Frog Angles are known.—It often happens that the engineer has at his disposal but a limited assortment of frogs. In such a case the turnout may be constructed as a compound curve to fit the given frogs. In Fig. 34 let

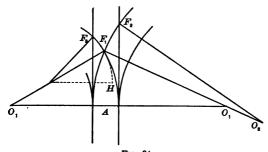


Fig. 81.

 F_1 , F_2 , and F_3 represent the frog angles that are to be used, R_1 , R_2 and R_3 the radii of middle line of track having centers

at O_1 , O_2 , and O_3 . If the frog at F_1 be in the middle of the track,

$$O_1 = \frac{1}{4}F_1;$$
 then
$$R_1 = \frac{G \cos \frac{1}{2}F_1}{2(1 - \cos \frac{1}{4}F_1)}.$$

If O_2H be made parallel to O_1A_1

$$F_3 O_3 H = F_3 \; ;$$
 hence $R_3 + \frac{G}{2} = \frac{G}{2(\cos \frac{1}{2}F_1 - \cos F_3)^6}$

$$AF_1=R_1\tan\tfrac{1}{3}F_1,$$

$$AF_3 = \left(R_3 + \frac{G}{2}\right) \sin F_3 + (R_1 - R_2) \sin \frac{1}{2}F_1,$$

and the distance AF_2 and radius R_2 may be computed in a similar manner.

$$R_2 + \frac{G}{2} = \frac{G}{2(\cos \frac{1}{2}F_1 - \cos F_2)}$$

and $AF_2 = \left(R_2 + \frac{G}{2}\right) \sin F_2 - (R_2 - R_1) \sin \frac{1}{2}F_1$.

The solution of nearly all problems in compound curves is simplified by continuing one of the curves until its central angle equals the total intersection angle between the tangents to the compound curve.

As an example, let it be required to locate a double turnout in opposite directions, using frog angles $F_1 = 28^{\circ} 20'$, $F_2 = 17^{\circ}$, and $F_3 = 21^{\circ} 17'$.

$$R_1 = \frac{4.708 \times .96959}{2 \times .03041} = 75 \text{ feet,}$$

$$R_2 = \frac{4.708(1 - .96959 + .93180)}{2(.96959 + .93180)} = 60 \text{ feet,}$$

$$R_3 = \frac{4.708(1 - .96959 + .95630)}{2(.96959 - .95630)} = 174.8 \text{ feet;}$$

$$AF_1 = 75. \times .2524 = 18.93 \text{ feet,}$$

$$AF_1 = 75. \times .2524 = 18.93$$
 feet,
 $AF_2 = 62.35 \times .36298 + 15 \times .24474 = 26.32$ feet, and
 $AF_2 = 177.2 \times .29287 - 99.8 \times .24474 = 27.4$ feet.

It is possible to locate such a turnout having F_1 F_2 , and F_3 equal, but F_1 must always be less than F_2 plus F_3 .

Prob. 22. What frog number and angle and frog distance are suitable for a turnout from a straight track of "narrow gauge," or 3 feet, when the radius of middle line of turnout is 50 feet?

Prob. 23. In a double turnout in opposite directions R_1 and R_2 are each 75 feet. Find F_1 , F_2 , AF_1 , and AF_2 .

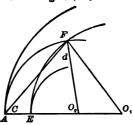
Prob. 24. A double turnout in opposite directions is composed of curves of 75 feet and 125 feet. Find frog angles and frog distances.

Prob. 25. Make the necessary computations for locating a double turnout when the three frog angles each are 17°.

Prob. 26. What must be the length of R_1 if R_1 be 100 feet when F_1 and F_2 are equal?

ART. 7. TURNOUTS FROM A CURVED TRACK.

(a) To locate a turnout on the Inside of a Curve when the Frog Angle is given.—In Fig. 85, R_1 is the radius of the mid-



dle line of the main track, R_1 that of the turnout, and F the frog angle or O_1FO_2 . In the triangle AFO_1 , $FAO_1 = 90^{\circ} - \frac{1}{2}(F + O_1)$.

Fig. 35.

$$AO_1 + FO_1 : AO_1 - FO_1$$

$$= \tan \frac{1}{2}(AFO_1 + FAO_1) : \tan \frac{1}{2}(AFO_1 - FAO_1),$$
or
$$\tan \frac{1}{2}O_1 = \frac{G}{2R_1} \cot \frac{1}{2}F,$$
also
$$\tan \frac{1}{2}O_1 = \frac{GN}{R_1},$$

in which G is the gauge of the track and N is the number of the frog.

In the triangle AFO_2 the angle at O_2 is $F + O_1$; hence

$$AF = (2R_2 + G) \sin \frac{1}{2}O_2,$$

also $EF = (2R_1 - G) \sin \frac{1}{2}O_1,$
and $cd = 2R_2 \sin \frac{1}{2}O_2.$

From the triangle FO_1O_2 ,

$$R_2 = \left(R_1 - \frac{G}{2}\right) \frac{\sin O_1}{\sin O_2} - \frac{G}{2},$$

and the middle line of the turnout may be staked out in the usual manner.

For example, let the radius of the main track be 125 feet and the frog angle 17°. Then $\tan \frac{1}{3}O_1 = \frac{4.708}{250} \times 6.6912$, $O_1 = 14^{\circ} 22'$, and $O_2 = 31^{\circ} 22'$; $EF = (250 - 4.708) \cdot 12504 = 30.74$ feet, and $R_2 = 122.65 \frac{24813}{52051} - 2.35 = 56.15$ feet.

(b) To locate a turnout on the Inside of a Curve when the Radius of the Turnout is given.—In Fig. 85 the three sides of the triangle FO_2O_1 are known; hence

$$\tan \frac{1}{2}F = \sqrt{\left(R_1 - R_2 - \frac{G}{2}\right)\frac{G}{2R_1R_2}}$$

After F is determined the other values are found as in the last paragraph (a).

For example, let it be required to select a frog to fit a turnout of 50 feet radius on the inside of a curve of 100 feet radius.

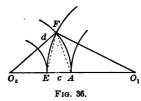
tan
$$\frac{1}{3}F = \sqrt{(100 - 50 - 2.35)\frac{2.35}{5000}}$$
 and $F = 17^{\circ}$.

(c) To locate a turnout on the Outside of a curve when the Frog Angle is given.—The formulas for this case are very similar to those in (a). In Fig. 36, $FO_1 = R_1 + \frac{G}{2}$, and

$$AO_1=R_1-\frac{G}{2}.$$

Also in the triangle AFO1,

$$AFO_1 = 90^{\circ} - \frac{F}{z} - \frac{O_1}{2},$$
 and $FAO_1 = 90^{\circ} + \frac{F'}{2} - \frac{O_1}{2};$ hence $\tan \frac{1}{8}O_1 = \frac{G}{2R_1} \cot \frac{1}{2}F = \frac{GN}{R_1};$ $O_1 + O_2 = F.$



In the triangle AFO2,

$$AF = (2R_{2} + G) \sin \frac{1}{2}O_{2}.$$
In EFO_{1} , $EF = (2R_{1} + G) \sin \frac{1}{2}O_{1}$,
In $O_{2}FO_{1}$, $R_{2} = \left(R_{1} + \frac{G}{2}\right) \frac{\sin O_{1}}{\sin O_{2}} - \frac{G}{2}$.

The distance from F to O_2O_1 was given in the article on double turnouts.

(d) To locate a turnout on the Outside of a curve when the Radius of the Turnout is given —In Fig. 36 the three sides of the triangle O_1FO_2 are known, and

$$\cos \frac{1}{2}F = \sqrt{\frac{R_1 R_2}{\left(R_1 + \frac{G}{2}\right)\left(R_2 + \frac{G}{2}\right)}},$$

since the frog angle is the supplement of O_2FO_1 .

For example, let the radii of the main and turnout curves be 75 and 50 feet respectively; then $\cos \frac{1}{8}F = \sqrt{\frac{3750}{4049.3}}$, and $F = 31^{\circ} 33'$; $\tan \frac{1}{8}O_1 = \frac{4.708}{150} 3.5398$, or $O_1 = 12^{\circ} 40'$ and $O_2 = 18^{\circ}53'$; AF = (100 + 4.708).16405 = 17.17 feet.

Prob. 27. The radius of the main track is 80 feet, and N is 3.5. Find the radius of the turnout on the inside, and the chord to the outside rail from the frog to the beginning of the turnout curve.

Prob. 28. The radius of the main track is 75 feet and that of the turnout on the inside is 45 feet. Find the chord ΔF from the frog to the P. C. C.

Prob. 29. It is required to determine the length of the chord on the middle line of a turnout of 60 feet radius, on the outside of a curve of 100 feet radius, between a point opposite F and the P. C. C.

ART. 8. SIDINGS AND CROSSOVERS.

(a) To connect a Siding with a Straight Track when the Distance between the tracks and the Frog Angles are given.—
The curved track AB in Fig. 37 is the crossover from the

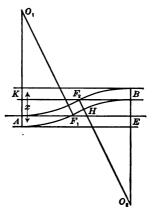


Fig. 87.

track AE to the track BK. The radii O_1A and O_2B may or may not be equal and the tangent F_1H may be omitted, forming a reverse curve, or the curves may be continued beyond F_1 and F_2 . The same form of curve is used in passing from a main track to a siding as shown in Fig. 87 with the straight track BK removed. In the figure the curves end at the frogs,

so AO_1F_1 is the given frog angle, and the distance between the middle lines of the straight track is x. Then

$$R_1 = R_2 = \frac{G}{2} \cot_2 \frac{1}{2} F_1,$$
or
$$\left(R_1 + \frac{G}{2}\right) = \frac{G}{1 - \cos F}$$

$$2 R_1(1 - \cos F_1) + F_1 H \sin F_1 = x,$$
and
$$(2R_1 + G) (1 - \cos F_1) = 2 G;$$
hence
$$F_1 H = \frac{x - G(1 + \cos F_1)}{\sin F_1}.$$

When the crossover is in the form of a reverse curve F_1H is zero and

$$x = G(1 + \cos F_1).$$

$$AE = 2R_1 \sin F_1 + F_1 H \cos F_1,$$

from which it is seen that the length of the crossover varies with the radius and with the distance between the tracks,

For example, let it be required to design a crossover in the form of a reverse curve between two tracks which are 4.5 feet between inner rails. In this case x = 4.708 + 4.5 = 9.208 feet.

$$\cos F = \frac{4.5}{4.708} = .9558$$
, so $F = 17^{\circ}$ 06". Then $R = 4.708 + .04421 - 2.354 = 104.1 feet.$

When it is convenient to have AE as short as possible, still using the given frog angles and distance between tracks, the curves are continued beyond the frogs as shown, and the tangent between the curves may be assumed within certain limits. In Fig. 38 let t represent the tangent LH between the curves, and P the middle point of t. Then

$$O_1P = \frac{1}{3} \sqrt{4R^2 + t^2},$$

 $\tan PO_1L = \frac{t}{2R}.$

and

Since P is midway between the tracks.

$$O_1P\cos PO_1A=\frac{2R_1-x}{2O_1P},$$

and

$$\cos PO_1 A = \frac{2R_1 - x}{\sqrt{4 R^2 + t^2}},$$

$$O_1 = PO_1 A - PO_1 L.$$

The tangent t will be less than F_1H , Fig. 37, as given above. For example, it is required to locate a crossover between

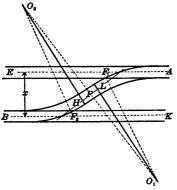


Fig. 38.

parallel tracks, 12 feet center to center, using 18° 41′ frogs and 10 feet of tangent between the curves. $R_1 = \frac{1}{8} \times 4.708 \times 8.3347^{2} = 163.5$ feet; tan $PO_{1}L = 10 \div 327.0 = .03058$, and $PO_{1}L = 1^{\circ} 45'$. Then $\cos PO_{1}A = (327 - 12.0) \div \sqrt{327^{2} + 100} = .96186$, and $PO_{1}A = 15^{\circ} 53'$. The angles O_{1} and O_{2} are $PO_{1}A - PO_{1}L = 14^{\circ} 08'$, or $0^{\circ} 27'$ beyond the frogs.

(b) When the Radii and Distance between tracks are given.

—In this case the method is the same as when the frog angles are known, since the latter may be expressed in terms of the former.

$$\cos F_1 = \frac{2R_1 - G}{2R_1 + G}$$

and the other computations are the same as above.

(c) To locate a Crossover between parallel Curved Tracks
when the Frog Angles and Distance between tracks are given.
In Fig. 39 the curves of the turnout are extended beyond

the frogs and connected by a tangent LII, while the fr g angles are unequal. In the triangle O_1PO , $OP = R + \frac{x}{2}$, $O_1O = R_1 + R$, and $O_1P = R_1 + \frac{1}{2}\sqrt{4R_1^2 + t^2}$, when R is the

radius of the inner main track, R_1 that of the curve AL, x the

O₁

Fig. 39.

distance between tracks, and t the tangent HL. The three sides of the triangle are then known, since R_1 is determined from the frog angle; and letting s represent the half sum of sides,

$$\cos PO_1O = rac{2s(s-PO)}{O_1O \cdot O_1P} - 1,$$
 $\cos POO_1 = rac{2s(s-O_1P)}{O_1O \cdot OP} - 1.$ In PO_1L , $\tan PO_1L = rac{t}{2R_1},$ and $O_1 = PO_1O - PO_1L.$

In the triangle PO_2O , $PO_2 = \frac{1}{3}\sqrt{R_2^2 + t_2}$, $O_2O = R + x - R_2$, and $OP = R + \frac{x}{2}$; so the cosine of POO_2 may be written as before,

$$\cos PO_2O = \frac{2s(s - PO)}{OO_2 \cdot PO_2} - 1,$$

$$\cos POO_2 = \frac{2s(s - PO_2)}{OO_2 \cdot PO_2} - 1.$$

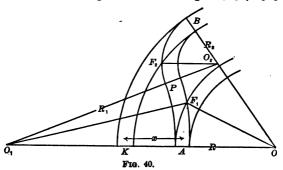
and

Then
$$O_2 = 180^{\circ} - PO_2O - PO_3H$$
,

and $KB = 2(R+x) \sin \frac{1}{2}(BOP + POO_1)$.

The crossover may then be run from either A or B.

The crossover is very often located in the form of a reverse curve, as shown in Fig. 40. In the triangle $O_1O_2O_1$, O_1O_2



 $R_1 + R_2$, $O_2O = R + x - R_2$, and $O_1O = R + R_1$. Therefore

$$\cos O_2 O_1 O = 1 - \frac{x \left(R - R_2 + \frac{x}{2}\right)}{(R + R_1)(R_1 + R_2)},$$

also
$$\cos O_2 O O_1 = 1 - \frac{x \left(R_1 + R_2 - \frac{x}{2}\right)}{(R + R_1)(R + x - R_2)}$$

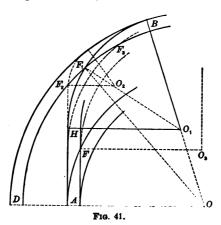
Then $PO_2B = O_2 = O_1 + O_2$

The point B may be located from K by deflecting $\frac{1}{8}O$ from the tangent at that point and measuring the chord $KB = 2(R + x) \sin \frac{1}{8}O_3OO_1$.

For example, $F_1 = F_2 = 17^\circ$, R = 150 feet, and x = 10 feet. Required to connect the two tracks by a crossover in the form of a compound curve. From Art. 7, (c), $\tan \frac{1}{2}F_1OO_1 = 4.708 \times 6.691 + 300 = .10500$, and $F_1OO_1 = 12^\circ 00'$. $FO_1O = 17^\circ - 12^\circ = 5^\circ 00'$. $R_1 = 152.85 \frac{2079}{.0872} - 2.85 = 360.9$ feet. From Art. 7, (a), $\tan \frac{1}{2}F_2OB = 4.708 \times 6.691 \div (150 + 19)2$, and $F_2OB = 11^\circ 14'$;

$$R_2 = (160 - 2.85) \frac{.1948}{.4731} - 2.35 = 62.6 \text{ feet}; \cos PO_1O = 1 - \frac{10.150 - 62.6 + 5)}{(159 + 360.9)(360.9 + 62.6)}, \text{ and } PO_1O = 5^{\circ}18'; \cos O_2OO_1 = 1 - \frac{10.360.9 + 62.6 - 5)}{(150 + 360.9)(150 + 10 - 62.6)}, \text{ and } O_2OO_1 = 23^{\circ}40'.$$
Then $KB = 2(150 + 10) = 65.62$ feet.

The crossing shown in Fig. 41 is in common use and avoids



the somewhat obj ct'onable reverse curve. The angle of the frog F is constant for the curve of radius AO, while that for the frog on the outer track may be assumed between the limits O_2F_2O and O_2F_2O ; when x is nearly 2G, F may be used in both places. Then, from Art. 6,

$$\cos F = \frac{2R - G}{2R + G},$$

in which R is the radius of the inner track.

From Art. 7, (a),

$$\tan \frac{1}{2}BOF_1 = \frac{G}{2R}\cot \frac{1}{2}F_1,$$

$$BO_1F_1 = F_1 + BOF_1.$$

and

Then
$$BO_1$$
 or $R_2 = \left(R_1 - \frac{G}{2}\right) \frac{\sin BOF_1}{\sin BO_1F_1} - \frac{G}{2}$.
From Art. 3, (c), $\cos BOA = 1 - \frac{x}{R_1 - R_2}$;
$$AH = (R_1 - R_2) \sin BOA$$

in which R_1 is the radius of the outer track. The point B may be located by measuring the computed chord DB deflected $\frac{1}{2}BOD$ from a tangent at D.

For example, let the radius of the outer track be 100 feet and x be 9.21 feet. $\cos F = \frac{176.876}{186.292} = .9495$; $F = 18^{\circ}$ 18'; $\tan \frac{1}{2}BOF_1 = \frac{4.708}{200}$ 6.2085, $BOF_1 = 16^{\circ}$ 38', and BO_1F_1

$$= 35^{\circ} 56'. \text{ Then } R_2 = 97.65 \frac{28625}{58684} - 2.35 = 45.28; \cos BOA$$

$$=1-\frac{9.21}{54.72}-2.35=\cos 33^{\circ}$$
 44'. The distance along the

straight track to the point of the connecting curve, H, is $AH = 54.72 \times .55533 = 30.37$, and in this case H is between the rails of the outer track, but the assumed frog angle is practically correct.

Prob. 30. Given: $F_1 = F_2 = 10^{\circ}$ 00'. Find the radius of the turnouts and the length of the connecting tangents.

Prob. 31. When the distance between tracks is 10 feet, find radius and frog angle necessary for a crossover in the form of a reverse curve.

Prob. 32. If the radius of the inner track be 100 feet, the distance between tracks 9.21 feet, and the frog angles 17, find the distance KB in Fig. 39.

CHAPTER III.

CONSTRUCTION.

ART. 9. LOCATION.

The preliminary survey of a street railroad consists generally of a series of straight lines, run as nearly as may be to the proposed location of the road, the lengths, azimuths, and profiles of which are determined in the field. The length of the line is the principal factor of the first cost, and the grade is one of the most important items of the operating expenses of the road. The azimuths, or directions of the lines, are necessary for making a map showing the location of the road with reference to street or property lines or other objects upon which the position of the road must depend.

In cities, the streets are usually selected which will afford the largest amount of patronage regardless of other considerations, and the grades on such seldom if ever exceed that over which electric cars may be run. Examples of six per cent grades are numerous, and some of over twelve per cent are in existence. The limiting grade is that down which a car can be made to move under such perfect control of the motorman that a full stop may be effected within less than fifty feet from the place where the brakes are applied. The speed at the top of the grade of course materially affects the distance within which a car may be brought to a standstill, as will also the efficiency of the brakes and the skill of the motorman. Another important consideration in deciding whether or not a hill is suitable for a street-car line is the amount of traffic to be encountered at the base of it. If at the foot of the grade a crowded thoroughfare runs at right angles to the road, the necessity of perfect control is apparent, and the risk from any lack of it is vastly greater than where the danger is confined

to the car itself and its passengers, as is the case in the open country, where a great momentum simply has the effect of propelling the car at a high speed along an unobstructed track.

The cost of construction of a road through the country is materially lessened by allowing the use of heavy grades, since the length is decreased or the amount of excavation and embankment is reduced to a minimum. The economy in first cost is offset by the increased expense of operation, which is due not only to the extra amount of power necessary to raise the car through the given distance, but to the fact that each car must be equipped with powerful motors which are required only on the grades and add so much useless weight to be carried over the remainder of the line, and for which provision must be made in designing the bridges, culverts, and whole substructure. The following formula is given by Dr. Louis Bell as representing the number of horse-power required to drive a car at the rate of eight miles per hour on any grade:

H. P. = .43
$$W(1+G)$$
,

in which W is the weight of car and load in tons, and G is the per cent of grade. On straight, level track the tractive effort is considered as twenty pounds per ton.

In selecting the curves there are many things to be taken into consideration; the sharper the curves the more nearly the line may be made to conform to the contours, and hence there results but little necessary excavation; on sharp curves each rail has to be bent to the proper form at the mill and shipped in that condition at an increased cost, so it is desirable that the curve be as sharp, and therefore as short, as possible. Rails may be bent to a curve of 1000 feet radius or over by springing one end after the other has been spiked in place, and a portable bender is efficient for heavy rails on curves of radius not less than 300 feet. For sharper curves the 9" girder rails must be run through heavy bending machines. The amount of traction on a curve as compared with that on a tangent is not very definitely known for curves of small radius; the prac-

tice on steam railroads is to reduce the amount of grade per hundred feet by from 0.03 to 0.05 feet for each degree of curvature, or about three inches on a curve of 1000 feet radius. It is stated on good authority that a curve of fifty feet radius doubles the traction and, in unfavorable circumstances, often increases it threefold. The practical effect of curves is to cause more or less discomfort to passengers, to greatly diminish the rate of safe speed, and to effect a wear and tear of track and car far in excess of that on tangent. All of these results are, to a great extent, prevented by the use of a curve of varying radius, as will be explained in a following paragraph.

As a car passes rapidly around a curve it is acted upon by gravity and by centrifugal force. The former causes a vertical pressure upon the rails, and the latter a tendency to horizontal movement of the whee! flange toward the outer rail.

The latter motion is counteracted by decreasing the speed or by elevating the outer rail with reference to the inner one, thus causing a horizontal component of the weight to oppose the centrifugal force. In Fig. 42 let o be the center of

Then

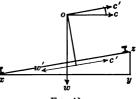


Fig. 42.

gravity of the load w on the rails x and z; then c' and w' are respectively the components of the centrifugal force and of the weight, acting in opposite directions along the inclined plane az. From similar triangles,

$$c' \colon c = xy \colon xz,$$

$$w' \colon w = zy \colon xz.$$
Then
$$zy = \frac{c \cdot w' \cdot xy}{c' \cdot w};$$
for equilibrium
$$c' = w'.$$

If V be the speed in feet per sec nd, and R the radius of the curve in feet.

$$c = \frac{wV^2}{32.2R}$$

After substitution,

$$zy=\frac{V^2.\ xy}{32.2R}.$$

The distance xy is very nearly the gauge G of the track, and zy = e is the elevation of the outer rail in feet, the expression for which becomes

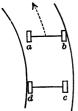
$$e = \frac{V^2 G}{32.2R},$$

or
$$e = .815 \frac{V^2}{R}$$
,

when V is the velocity of the car in miles per hour.

The elevation e is relative to the inner rail, and not to the middle line of the track, it being the custom to depress the inner and raise the outer rail by half of e.

For example, let it be required to compute the proper elevation of the outer rail on a curve of 200 feet radius and speed of ten miles per hour. By substitution, $e = .815 \times 100 \div 200 = 0.16$ feet. For a radius of 50 feet e would be 0.63 feet, which would be impossible in city streets, where one inch might be the maximum possible; then the speed should be reduced to correspond. $V^2 = 3.17eR$, and when e is one inch the speed should not be above four miles per hour on a curve of 50 feet radius. On sharp curves the rear wheel of the car



does not touch the outer rail, owing to the fact that the velocity is always low, and as a result the position of the car is cornerwise, the front outer and rear inner wheels pressing hard against the rails.

The trucks on most street cars are fixed so that the axes are parallel, and hence they cannot be on radii of the curves, but assume

Fig. 43. a position as shown in Fig. 43. a, b, c, and d represent the part of the flanges of the wheels below the top of the track. As the car moves in the direction indicated by he arrow the flanges of the wheels b and d are pressed closely

against the rails, while those of a and c may not touch at all.

Accordingly it is the custom to make the gauge on curves a fraction of an inch wider than on tangent, depending upon the length between axles ad of the cars in use for the exact amount, and a guard-rail $\frac{1}{4}$ inch to $\frac{1}{2}$ inch higher than the rail is used inside the inner rail of the curve.

Another consideration in regard to curves is that concerning the distance between tracks if cars are to be allowed to pass at such points. The position of two cars meeting on a curve is shown in Fig. 44, and the necessity for increasing the distance between

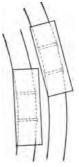


Fig. 44.

the tracks is apparent. The distance between centers should seldom be less than 10 feet on curves of 50 feet radius, and 12 feet is often specified.

Prob. 33. What is the proper elevation of the outer rail of a curve of 500 feet radius and for velocity of 15 miles per hour?

ART. 10. TRANSITION CURVES.

The use of spiral instead of circular curves on street railways is properly becoming general, to the advantage of owners as well as of patrons of the road. Some of the reasons for adopting this form of curve have been enumerated, and to these must be added the necessity for elevation of the outer rail. On one side of the point of curve the track is straight, and hence the rails should be of equal elevation; just beyond, the outer rail, being on a curve, should be elevated as shown above, and hence, to fulfill these requirements, there would be an abrupt rise from the tangent to the curve, which is impracticable. The result with circular curves is that the rail must be improperly raised for a short distance back on the tangent, while the first part of the curve is not high enough.

In order that the elevation of the outer rail may be uniformly increasing from zero at the beginning, to the computed amount

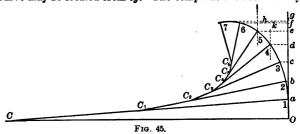
at the end of the spiral or transition curve, the radii must diminish in the same ratio, since R varies inversely as c. If 300 feet be assumed as the radius at the beginning of the transition curve and five feet the length of the chords, the several radii will be 300 feet into

1,
$$\frac{1}{2}$$
, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, $\frac{1}{6}$, $\frac{1}{7}$, ..., $\frac{1}{n}$,

or 300, 150, 100. 75, 60, 50, 43 feet,

and the angles at the centers subtended by the chords may be computed.

In Fig. 45, 0, 1, 2, 3, 4, 5, 6, and 7 are stations 5 feet apart on the transition curve, and a, b, c, d, e, f, and g are points on the tangent opposite them. If the distances from each of these points from 0 and the offsets a1, $b2 \dots g7$ be known, the curve may be located from 0g. The computations are made by



considering perpendiculars from each point on the curve toward the tangent between the curve and a parallel to the tangent through the preceding station, as $5 \cdot k$ and $k \cdot 4$ in Fig. 45, the angle between the chord and the parallel to the tangent being the sum of the central angles subtended by the preceding chords and half the central angle subtended by the chord itself, or

then
$$5-4-k = C_0 + C_1 + C_2 + C_3 + \frac{1}{2}C_4;$$

$$5-k = 5.0 \frac{217}{645} 5-4-k,$$
and
$$4-k = 5.0 \frac{205}{645} 5-4-k.$$

The tangent distances and offsets from the tangent, as 0e and 5-e, are found by continued additions of the distances, just computed as shown in the table.

	Central Angle.	Chord.	Angle with Tangent.	Lati tude.	Longi- tude.	Tangent Distance.	
ರಿ ಬೆಳೆ ಬೆಳೆ ಬೆಳೆ ಬೆಳೆ ಬೆಳೆ ಬೆಳೆ ಬೆಳೆ ಬಿಳೆ ಬಿ	0° 57′.3	0-1	0° 28'.65	5.00	0.04	5.00	0.04
	1 54 .6	1-2	1 54 .6	5.00	0.17	10.00	0.21
	2 51 .9	2-3	4 17 .8	4.99	0.87	14.98	0.58
	3 49 .2	8-4	7 88 .4	4.96	0.66	19.94	1.25
	4 46 .6	4-5	11 56 .3	4.89	1.08	24.83	2.28
	5 43 .9	5-6	17 11 .5	4.78	1.48	29.61	3.76
	6 40	6-7	28 28 .5	4.59	1.99	84.20	5.75

The tangent of the deflection at 0 from the tangent to any station may be computed from the last two columns thus:

$$\tan d \cdot 0.4 = 1.25 \div 19.94$$
; angle $d \cdot 0.4 = 3^{\circ} 35'$.

It often happens that from the P. C. an unobstructed view around the entire curve is impossible, and the deflections from other stations than 0 may be computed from the tangent distances and offsets. The angle between $k\cdot 4$ and $0\cdot 4$ is 3° 35′, and the tangent $5\cdot 4\cdot k = 5\cdot k + k\cdot 4$, so $5\cdot 4\cdot k = 11^\circ 56'$. Then the deflection from $0\cdot 4$ produced to the chord $4\cdot 5$ will be

$$h-4\cdot5 = (k\cdot4\cdot5) - (d\cdot0\cdot4)$$
 and
$$h-4\cdot6 = (k\cdot4\cdot6) - (d\cdot0\cdot4)$$
 also
$$\tan (0\cdot4\cdot2) = (d\cdot4) - (b\cdot2) + (0\cdotd)(0\cdot5).$$

In like manner the deflections from each station to every other station on the curve may be computed.

In making the table of deflections for transition curves the same arrangement has been observed as in keeping the notes on simple curves; that is, the line of sight must always be in such a position that the vernier will indicate zero when the instrument is pointed toward the beginning of the spiral.

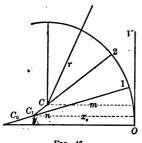
As an example of the use of the table let the location of the curve be such that only the first three stations can be seen from station zero. The deflections from the tangent at zero are given in the horrizontal line opposite "Instrument at O," and the stations 1, 2, and 3 are located five feet apart. The instrument is then moved to station 3, and the back sight may be taken on either of the stakes already located, the vernier

TABLE OF	DEFLECTION			WHEN
	тне Сно	$ord = R_1$	÷ 60.	

Sta. 0	Sta. 1	Sta. 2	, Sta. 3	Sta. 4	Sta. 5	Sta. 6	Sta. 7
	R = 60C	R = 80C	R = 20C	R = 15C	R = 12C	R = 10C	R=8.6C
Ins. at 0 0° 00' 0 00 0 00 0 00 0 00 0 00 0 00	Ins. at 1	1° 12′ 1 26 Ins. at 2 2 04 2 23 2 42 8 01 8 21	2° 14′ 2 38 3 06 Ins. at 3 4 04 4 82 5 01 5 80	3° 35′ 4 08 4 46 5 25 Ins. at 4 6 41 7 20 7 58	5° 15′ 5 58 6 46 7 34 8 21 Ins. at 5 9 57 10 45	Ins. at 6	9° 32′ 10 85 11 42 12 49 13 55 15 02 16 09 Ins. at 7

being set at the angle in the column for the station where the back-sight is taken and in the line for the instrument at the given station. In this case the vernier should be set at 2° 04', 0° 53, or 0° 00' according as the back-sight is to be at station 2. 1, or zero. Station 4 is fixed by setting the vernier to read 5° 25', plunging the telescope and measuring five feet from station 8.

If the central curve to which the transition is to be applied be of large radius, the above table applies equally well by increasing the length of the chords; as for example, let the main curve be of 500 feet radius, then the radii of the spiral might be taken at 3000, 1500, 1000, 750, and 600 feet respectively, while the chords would be $5 \times 10 = 50$ feet, and intermediate points may be fixed by an ordinate to the middle of each chord.



Frg. 46.

The coordinates of the centers are useful in computing the tangent and external distances of the curve, and the method of calculation is readily understood from the figure. Let $C_0, C_1 \ldots C_0$ be the centers of the curves forming the spiral, and x_0y_0 , x_1y_1 ... $x_{\bullet}y_{\bullet}$ be the respective coordinates; also let C and $m \cdot n$ represent the center and coordinates

of the center of the main curve of radius r between the two

transition spirals; then	the	latter	may	be computed	from	the
following table:						

Center.	Angle with Ra.	Coordinates.			
		æ	v		
C, C,	0° 57′ 18″ 2° 51′ 54 5′ 43′ 48	800.00 feet 150.00 100.06	0.00 feet 2.50 5.00		
C, C	9 33 00 14 19 84 20 03 80	75.19 60.41 50.71	7.50 9.99 12.46		
Č.	26 48 28	44.18	14.86		

The second column gives the angle that each radius (profuced) makes with the first radius $C_0 - O$; in the third and courth columns are the distances from each center to C_0O and OV respectively. Then the coordinates m and n are found.

$$m = x - (R - i) \cos \alpha,$$

and
$$n = y + (R - r) \sin \alpha,$$

in which $x \cdot y$ is the center of the arc of the spiral that joins the middle curve, R is the radius of the last arc of the spiral, r is the radius of the main curve, and α is the inclination of the radius at the end of the spiral to R_0 as given in column two of the above table.

Then
$$T = n + m \tan \frac{1}{2}I$$
,
and $E = r \operatorname{exsec} \frac{1}{2}I + (m - r) \div \cos \frac{1}{2}I$.

These values may be found for any intersection angle when r is known.

For example, let $I=88^\circ$ 30' and r=55.0 feet; then C_4 is the center of the last arc of the spiral, and $\alpha=14^\circ$ 19' 34"; $m=60.41-(60-55)\cos 14^\circ$ 19' 34" = 55.60 feet; $n=9.99+5\sin 14^\circ$ 19' 34' = 11.23 feet; T=11.28+55.6 tan 44° 15' = 65.40 feet.

It may often be desired to determine the radius of the central curve to correspond with a given tangent or external distance, and the above formulas may be stated in terms of r.

$$r = \frac{T - y - R \left(\sin \alpha - \cos \alpha \tan \frac{1}{2}I\right) - x \tan \frac{1}{2}I}{\cos \alpha \tan \frac{1}{2}I - \sin \alpha},$$

also
$$r = \frac{E \cos \frac{1}{2}I - x + R \cos \alpha}{\cos \alpha - \cos \frac{1}{2}I},$$

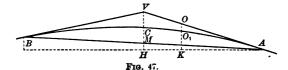
from which r may be found for assumed values of T or E. By finding the radius of a simple curve having the given tangent, some idea may be formed as to the value of R, which will usually be the one on the spiral next smaller than the computed radius, T cot $\frac{1}{2}I$. When R has been determined, x, y, and α are taken from the table and the above equations are solved for r. If the value of r thus determined be between the assumed R and that next smaller in the spiral, the assumption is correct; if not, another value of R may be chosen and corresponding values of x, y, and α used.

For example, let I be 73° 32' and T=50 feet, to determine the value of the central radius. The radius of the simple curve, $T \cot \frac{1}{8}I = 66.9$ feet, so R may be assumed as 60 feet. Then $\alpha = 14^{\circ}$ 20', x = 60.14 feet, and y = 9.99 feet; then

$$r = \frac{50 - 9.99 - 60(.247 - .969 \times .747) - 60.14 \times .747}{.969 \times .747 - .247},$$

or r=49 71 feet, which is so near 50 feet that the choice of R may be considered as correct. If, however, the result had been, say, 45 feet, it would be better to take R as 50 feet and make another computation for r.

Another variety of transition curve is that used to connect two grades of very different inclination; in this case the radius of the curve is in a vertical plane, and the curve is called a vertical curve. The object of the curve is to reduce



the shock occasioned by the sudden change in rate of grade, which is a cause of wear to track and rolling stock. The proper curve to use in such cases is the parabola. Let AV and VB be the profile of two adjoining grades, and ACB the

proposed parabola; also let VC be the vertical distance from the apex to the curve, and OO_1 any other vertical offset from the tangent to the curve. Whatever the difference in rate of grade, the horizontal distance between A and V is the same as that between V and B, since the line is always so measured on the ground. Then, since VC is an axis of the parabola,

$$VC = CM,$$

$$OO_{1}: VC = \overline{AK}^{2}: \overline{AH}^{2}:$$

and

or, letting E_1 , E_2 , and E_3 represent the elevations of A, V, and B, the elevation of M is $\frac{1}{4}(E_1 + E_3)$, and

$$CV = \frac{1}{2}(E_2 - M).$$

If CV becomes negative, it indicates that the curve is above the tangents.

$$CV = \frac{1}{3}(E_3 - \frac{1}{3}E_1 - \frac{1}{3}E_3),$$
 also $OO_1 = \frac{VC \cdot d^2}{h^2},$

in which OO_1 is any vertical offset from the tangent to the curve at a distance d from A or B, and h is the horizontal distance AV or BV.

For example, let it be required to replace the following grade by a vertical parabola. The elevations of stations 5 feet apart are A=100.0; 1=99.5; 2=99.0; V=98.5; 3=98.8; 4=99.1; B=99.4. Then $VC=\frac{1}{2}\cdot98.5-\frac{1}{2}\cdot100-\frac{1}{2}\cdot99.4$) =-0.6 feet. The offsets at 1 and 4 are $-0.60\times5^{\circ}\div15^{\circ}=-0.07$ feet; at 2 and 3, -0.27 feet, and the elevations on the curve are 100, 99.57, 99.27, 99.10, 99.07, 99.17, and 99.40 feet.

Prob. 34. If p and p' represent the rise per horizontal foot of track, d the distance from the beginning of the curve to any station, and h half the length of curve, prove the offsets from the tangents to the vertical curve are $\frac{d^2}{4h}(p-p')$.

Prob. 35. Given: Elevation of A = 100; the rate of fall from A to V = 9:100; the rise from V to B = 12:100. Find elevations on a vertical curve of three stations 5 feet apart on each side of V.

Prob. 36. When $I = 91^{\circ}$ 30', what central radius must be used with transition curves at each end that the external distance may be the same as with a simple curve of 75 feet radius?

Prob. 37. Make a page of field-notes for the curve found in the last problem, the instrument being placed at the point of spiral, at the P. C. and at the P. T. of the middle curve.

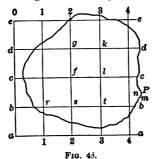
Prob. 38. Design a transition curve of seven stations to join a curve of 500 feet radius when $I=88^{\circ}$.

ART. 11. EARTHWORK COMPUTATIONS.

All volumes of earth are usually considered as being composed of prisms, wedges, and pyramids. When the sides of these figures are narrow, the appearance will be that of a curved or warped surface, as a pyramid becomes a cone when the number of the sides are sufficiently increased.

The railroad engineer has to deal with two classes of excavation: that of the earth between the surface of the ground and the finished subgrade of the roadbed; and of material from borrow-pits when the amount of filling exceeds that of cutting the earth down to the proposed grade, or when ballast is taken from a gravel-pit. The computations in the two cases differ somewhat from each other, and the latter will be considered first.

In Fig. 48 the irregular curve represents the edge of the



borrow-pit, and the intersections of the right lines show the points at which elevations are taken before and after the excavation is completed. The points on the lines aa and ae should be so fixed that they will not be disturbed, so that all the other lines may be re-established after the first stakes and material in the pit have been removed. The squares, as fghk, are usually made small enough that the surface may be assumed as a plane without material error; then if the letters on the corners represent the elevations of those points before the ground is disturbed, and f'g'k'l' the corresponding final elevations, the volume of fgkl - f'g'k'l' will be the product of the area of a right section and the mean of the heights of the corners of the square, or

$$V = \frac{A}{4}(f - f' + g - g' + k - k' + l - l').$$

When h cdots cdot hn are the various heights and A is the area of the horizontal section of any prism of n sides having plane ends, not necessarily parallel to each other,

$$V = \frac{A}{n}(h_1 + h_2 \ldots + hn),$$

in which V is the volume in the same unit as the linear dimensions and the area. Usually all are in feet, and afterwards the volume is found in yards by dividing by 27.

When several prisms of equal right section adjoin each other the volume of the whole may be computed in one operation, multiplying the height at each corner by the number of entire polygons meeting at that corner, then the sum of these products into the area of a right section of one prism divided by the number of sides of the prism will be the volume, or

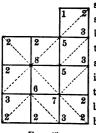
$$V = \frac{A}{4}(d_1 + 2d_2 + 3d_3 + 4d_4),$$

in which the prisms are of square section, d_1 is the sum of heights of corners common to one prism, d_2 , d_3 , and d_4 similarly are the sums of heights of corners common to two, three, and four prisms.

For example, let the corners be designated by the letters on the axes through them, as c2 for f and d3 for k. Then let, in Fig. 48, the depths of excavation at b1 = 6, b2 = 8, b3 = 10,

b4 = 8, c1 = 5, c2 = 7, c3 = 9, c4 = 2, d1 = 4, d2 = 6, d8 = 8. d4 = 1, e2 = 0, and e3 = 2. Then b1, b4, d1, d4, e2, and e4 are corners of but one prism each. Also b2, b3, c1, and c4 are common to two, d2 and d3 to three, and c2 and c3 to four prisms The volume will then be, if the squares be ten feet on a side, $V = \frac{190}{6}(6+3+4+1+0+2) \times 1 + (8+10+1)$ $5+2) \times 2 + (6+8) \times 3 + (7+9) \times 4 + 27 = 159.26$ cubic yards.

It is often impossible to so locate the corners of the square that the surface so included will be a plane. However, by con-



sidering each square as two triangles the surface may usually be fairly represented by two planes intersecting on diagonals of the rectangles. The computation is the same as above, the height at each apex being taken as many times as there are triangles around that point, and the area being one half of the rectangle. Or if A be the area of the rectangle and n=3, the

Fig. 49.

volume in cubic feet is

$$V = \frac{A}{6}(d_1 + d_2 + d_3 + d_4 + d_6 + d_6 + d_7 + d_8).$$

The proper direction of the diagonals is indicated in the note-book from observations in the field as shown in Fig. 49. the figures being the numbers by which the heights would be multiplied for that case.

The areas outside regular polygons are found by measurement in the field, the position of any point, as p, Fig. 48, being recorded b + m, 4 + n, when m and n are the distances of pfrom bb and 44, and the volume of each irregular figure is found by taking the mean of the corner heights into the area and dividing by the number of sides. It must be constantly remembered that this rule is true only where the top and bottom surfaces are approximately plane figures.

The excavation or embankment along a line of railroad is computed from cross-sections taken at intervals of one hundred feet or less; the material being thus divided into figures

having parallel ends at the sections, and for sides the road-bed, the side slopes, and the original surface of the ground. The cross-sections are taken so near together that the ground surface may be, without material error, considered as generated by a right line touching the upp r edges of the end sections. Such a figure may be divided into pyramids, wedges, and prisms having as a common height the distance between the sections, and is given the name Prismoid.

The Prismoidal Formula is an expression giving, at one operation, the volume of a group of prisms, wedges, or pyramids having a common altitude between parallel ends.

Let A be the lower base, a the upper base, M the area of a section midway between the bases, and l the distance between the bases; then the volumes will be

Prism =
$$A \times l = \frac{l}{6}(A + 4M + a)$$
.
Pyramid = $A \times \frac{l}{3} = \frac{l}{6}(A + 4M + a)$;
Wedge = $A \times \frac{l}{2} = \frac{l}{6}(A + 4M + a)$;

in which A = a in the prism and a = zero in the wedge and pyramid; also M = A, $\frac{1}{4}A$, and $\frac{1}{4}A$ in the prism, pyramid, and wedge respectively.

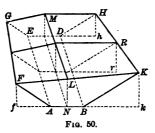
In railroad work it is usual to compute M as a section whose linear dimensions are the mean of the corresponding lines at the end sections; this is correct when the end sections are similar figures, and hence they should be taken at frequent intervals. In Fig. 50, ABDE represents the finished road-bed, AFGE and BKHD the side slopes, ABKF and DEGH the end cross-sections, and FGHK the original ground surface. In the field, at each section, the middle height LN, the side heights Kk and Ff, and the distances of F and K from the middle line fN and kN are determined by measurement. Then the areas of the cross-sections are

$$A = \frac{1}{4}C(h_1 + h_2) + \frac{1}{4}(d_1 + d_3)b_1$$

in-which C is the middle height, h_1 and h_2 horizontal distances from the middle to the side stakes, or Nf and Nk, and b the width of the road-bed. The middle area M is computed from linear dimensions as

$$Rr = \frac{1}{2}(Hh + Kk)$$

substituted in the above formula, and a is found from the measured dimensions of GEDH.



The field-work of cross-sectioning consists of setting stakes at points, as F, L, and K in Fig. 50. The elevation of N is previously determined from the profile, so C is known when the elevation of L is found, and the slopes are usually such that 3Kk = 2Bk, or "one and one-half to one." The side height, as Kk, is estimated as nearly as possible, and the corresponding distance from the middle line is computed

$$Nk = \frac{1}{4}b + 1\frac{1}{4}Kk.$$

This distance is measured out and the rod held at the assumed point; then if the cut Kk as determined from that rod reading is the same as that assumed in computing the distance Nk, the rod is at the proper place for the stake at K; if not, the result is a guide for a closer approximation, which should be very near the proper place.

The field-notes are kept as shown, the numerators being the side heights as Kk and Ff, positive if cut, and negative if fill, and the denominators being the distances from the side stakes to the middle.

Here the road-bed is, for double track, twenty feet wide in cut and fifteen feet wide in fill, the extra width in cut being

for ditches each side of the track. The slopes are 1½ to 1, and the volumes may be computed without further data if the distance between the stations, in this instance 100 feet be known.

Station.	Left.	Middle.	Right.
40	4.6 16.9	+ 8.2	$+\frac{10.8}{26.2}$
41	$\frac{00}{10.0}$	+ 6.6	$+\frac{7.4}{21.1}$
+ 20	$-\frac{1.2}{9.3}$	0.0	8.0 14.5
+ 60	$-\frac{4.6}{14.4}$	- 1.8	$\frac{0.0}{10.0}$
42	$-\frac{6.4}{17.1}$	- 4.2	$-\frac{0.8}{8.7}$

For example, to compute the volume between the sections at stations 40 and 41. Here $A = \frac{1}{4} \times 8.2(16.9 + 26.2) + \frac{1}{4} \times 20(4.6 + 10.8) = 253.71$ square feet; also $a = \frac{1}{2} \times 6.6(10.0 + 21.1) + \frac{1}{4} \times 20(00 + 7.4) = 139.63$ square feet. Then $M = \frac{1}{4} \times 7.4(13.45 + 23.65) + 5(2.3 + 9.1) = 194.27$ square feet. The volume is $V = \frac{120}{2}(253.71 + 777.08 + 139.63) = 19,507$ cubic feet = 922 5 cubic yards.

When the road-bed passes from cut to fill, as between stations 40 and 42 in the above table, it is neces-

40 and 42 in the above table, it is necessary to take three cross-sections as shown in Fig. 51, where the middle line and each of the sides of the road-bed pass through the points of no cut and no fill, or at stations 41 + 00, 41 + 20, and at 41 + 60. The volume of the excavation is then ABL-MFK and MFK-C, the latter being a pyramid. Also the filling is composed of two figures, the pyramid A-JME and IDC-JME, and sufficient data are given in the notes to enable the engineer to compute the total volumes.

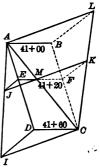


Fig. 51.

A practice which has been very general, and which is recognized by the courts of some States, is to consider the volume as the product of the length and the mean of the two end areas. The result of this method of computation is always too large, if the sections have been taken at proper points, unless the sections are exactly the same. The excuses for the custom are that the discrepancies to which it gives rise are small as compared with other unavoidable ones, such as classification of material into earth, loose and solid rock, and that the contractor should be given the benefit of the doubt.

As an extreme case let it be required to find the error involved in computing the volume of cut between stations 41+20 and 41+60 by the method of average end areas. Here $A=10\times3.0\times\frac{1}{8}=15.0$ square feet, and a= zero, so $V'=\frac{1}{8}(15+0)\times40=300$ cubic feet. Since the figure is a pyramid the true volume is $V=15\times\frac{1}{8}\times40=200$ cubic feet, and the error is hence fifty per cent. A similar error, but not so marked, will result when one section, although not zero, is considerably smaller than the other, and only when the sections are approximately equal will results sufficiently correct be obtained by this method of computation; and hence the profile as well as the cross-section should determine the frequency with which the latter should be taken.

Prob. 39. Compute the amount of excavation between stations 40 and 41 by average end areas and by the prismoidal formula.

Prob. 40. Compute the amount of excavation between stations 40 and 41 by dividing into pyramids having vertices at the side-slope stakes.

Prob. 41. Given: Two level sections, thirty feet apart, having heights of four and six feet respectively, the road-bed ten feet wide, and slopes one and a half to one; compute the volume by the prismoidal formula and by average end areas.

Prob. 42. In Fig. 49, let the figures represent the amount of excavation in the upper left four squares; compute the volume by rectangles and by triangles.

ART. 12. ESTIMATE OF COST.

A standard statement of the cost of a street railroad, which will apply to all cases, is of course impossible. The various items only may be enumerated with accuracy since the prices are constantly changing, not only for varying dates, but for different localities, depending upon the prices of labor and upon the accessibility of the place of consumption to the source of supply. For these and other reasons the estimates of cost in this article are intended to serve only as examples giving approximate expense of the items named under given conditions.

The first cost of a line of a street electric railway may be divided properly into the following general items:

Franchise.
Right of Way.
Road-bed.
Overhead Structure.
Power Plant.
Rolling Stock.

The first item is one which, in this country, up to the present time has, at least nominally, usually been given by the people in exchange for the contemplated convenience of rapid transit, and with the provision that the railroad company shall make certain improvements, such as paving or surfacing the streets used by it. It is highly probable that in the near future, as increased skill and knowledge are attained, the operating expenses will be so reduced that interest may be earned on capital invested in electric railroads, even after paying some percentage of the receipts to the cities in return for the privilege of using the streets. When that time is reached the franchise will be salable and city governments will be prompt to take advantage of the fact.

The right of way through city streets is included in the franchise if the latter is bought. Through farming land the property must be bought outright, and near large towns and cities

the price may be from one hundred dollars to a thousand dollars per acre. The area of a mile of right of way is 0.1212 acres for each foot of width, or 1 acre for each width of 8½ feet; so at \$500 per acre and right of way 25 feet wide, the expense of this item would be \$1515. Damages to abutting property not actually occupied must be considered in determining the location of the line, and reduced as much as possible by changes in grade or alignment.

In the item of road-bed are included the excavation and embankment and ballast, also the ties, rails, and fastenings. The excavation may cost from 15c. in soft loam or gravel to a dollar in rock or in broken-stone roads. Ties are worth from 80c. to 75c., and are placed approximately two feet apart. The following bill of material is for a mile of single-track road, and is taken from The Street Railway Journal for December 1893, since which time prices have decreased somewhat. It will be noted that 70-pound rails are quoted, whereas the present practice is to use much heavier, and oak or chestnut ties might be substituted for those of spruce.

110 tons 70-lb. rails (including freight, inspection, and hauling) @ \$87.50	\$ 4125.00
@ \$2.01 per 100 pounds)	361.80
1700 track-bolts ($\frac{7}{4}$ " × $8\frac{1}{4}$ ") @ \$3.01 per 100 pounds	
6050 spikes $(5'' \times \frac{9}{18}'')$ @ \$2.46 per 100 pounds	148.88
11 M nut locks @ \$6.50 per M	
3017 spruce ties @ 55c	1659 35
360 bonds @ 25c	90.00
1320 tie-rods @ 20c	264.00
2347 cubic yards excavation (8' \times 18" deep) hauled	
off @ 30c	704.10
Track-laying @ \$1.59 per linear foot	1000.00
m-4-1	69419.97

In many places along the side of country roads where the excavation is only to the depth of about one foot, a good substantial railroad may be built for about one dollar per linear foot.

The bill given below is from *The Street Railway Journal* of March 26, 1896, for a mile of double-track street railway in a paved street in Chicago:

283 L. tons 9" 90-pound rails @ \$33	\$9839
4224 white-oak ties $5'' \times 8'' \times 7'$ @ 38c	1605
352 cast welded joints @ \$3.50	1282
1760 tie-rods @ 15c	264
33,792 spikes $\frac{1}{4}$ " $\times \frac{1}{4}$ " $\times 4\frac{1}{4}$ " @ 1c	888
42,240 feet wood-filler	2112
Labor at \$1 per linear foot	5280
10,560 square yards cedar blocks @ 30c	8168
146 square yards sand @ \$1.25	183
445 cubic yards broken stone @ \$1.50	668
10,560 square yards gravel and dressing @ 8c	845
10.560 square yards 2" hemlock boards @ 8c. per square	
yard	845
Total	25,879

If stone be substituted for wooden pavement, the expense will be \$12,708 instead of \$3168 and the total \$35,419.

The poles in the overhead system are spaced about ninety to the mile. The price of wooden poles varies from \$2.50 to \$3.50 each, while those of iron are from \$18 to \$27 apiece; the cost of setting them is from \$2 to \$2.50 each. Sawed poles with arms may be estimated at \$600 per mile. The wiring may be stated as follows: trolley wire \$700; feed wire \$1000; and return wire \$600. The total cost of the overhead system for a mile of single track may then be given in round numbers as \$3000 for wooden poles and \$5000 for iron poles.

The cost of power and equipment for an electric railroad varies approximately as the number of cars operated, and the following round numbers will serve as rough checks on an estimate in a given case:

Number	Cap	acity.	Cost.			
Cars.	н. Р.	н. Р. к. w.		Steam Electrical Cars Plant. Equipment Equip		
1	20	15	\$1000	\$700	\$ 3:500	

The cost for a small number of cars is, in general, somewhat larger than for many. The necessary number of cars per mile is governed by the rate of speed and the interval of time between them. Thus let the cars pass a given point in the same direction every 5 minutes, and let the average speed be 6 miles per hour; then each car must be half a mile ahead of the succeeding one; and if the same number pass in the opposite direction, the number per mile of road must be four.

Prob. 43. Make estimate of required capacity and probable cost of a power house for a single-track road over which it is proposed to run cars every 10 minutes each way at a rate of 8 miles per hour.

Prob. 44. Compute the cost per mile of excavating for an electric railway which is to follow the grade of a broken-stone street, the depth of excavation being 20 inches and the width 8 feet.

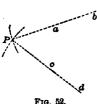
Prob. 45. Compute the cost of paving, with stone blocks, a mile of street, 80 feet between the curbs.

Prob. 46. Show that the number of gross tons of rails per mile of single track is eleven sevenths of the number of pounds per yard of rail.

ART. 13. SUPERINTENDENCE OF CONSTRUCTION.

Before any excavation is begun the line should be staked





out, and at the angles all intersectionpoints should be carefully referenced by
measurements to firm points, or by intersecting lines, so that they may be
readily replaced. On long curves the
points of curve and of tangency, and
also points at frequent intervals on tangent, should be preserved by reference.
In city streets the most convenient way
to do this is to use the curb as a reference, then the foreman may measure
offsets from the same points to line off
the edge of the excavation. In Fig. 52

are shown methods of locating a point so that it may be fixed

at any subsequent time. Let P be the given point, then from P the straight lines ab and cd are located outside the area to be excavated. Then at any time P may be relocated by finding, with the transit, the intersection of the lines ab and cd. Otherwise the same result may be attained by measuring accurately Pa and Pc; then P may be fixed by intersecting arcs of circles of radii Pa and Pc.

The bottom of the trench is called the subgrade of the road, and the material upon which the ties rest is the ballast. The preparation of the subgrade is an important factor in regulating the cost of future repairs. The use of the ground under the surface of the streets as a place for laying gas, sewer, water, and other pipes makes the work of securing a subgrade of uniform compactness very difficult. The trenches for the pipes should be wet and well tamped and the whole subgrade thoroughly rolled with a heavy roller to a grade very nearly parallel to the finished grade. It is usual on well-constructed roads to make the excavation about 22 inches deep, which depth leaves about seven inches of ballast under a 9-inch girder-rail and a tie six inches deep.

The best material for ballast is broken trap-rock of such size that it will just pass through a two-inch ring; this variety of stone breaks into very hard, sharp-edged fragments which do not readily wear smooth, and for this reason may be made very compact by rolling. The ballast is spread in layers in the trench, and each layer is rolled separately, preferably with a roller having a corrugated surface.

The ties may be of white oak or chestnut for best results, but yellow pine and hackmatack will often outlast the rails above them; the harder woods are preferred from the fact that they hold the spikes better. The standard size of ties is six inches deep, eight inches wide, and seven or, seldom, eight feet long; they may be either sawed or hewn with the grain, but the top and under surfaces should be nearly parallel. The ties are spaced according to the load, strength of the rail, and the width of the lower flange; the usual distance is three feet between centers, and in some cities the spacing is not uniform but the ties are placed nearer together at the rail-joints than

the middle of the rail. On the People's Traction Company's line in Philadelphia the ties are spaced as shown in Fig. 58, one being placed directly under the joint. The ties are of

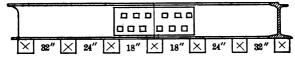


Fig. 58.

Georgia pine, seven feet long, and, except as shown in the figure, are evenly spaced, fourteen to each rail. On some roads the upper surface of the tie is protected from the rail by castiron tie-plates about six by ten inches in size and weighing about fifteen pounds each.

The weight and depth of rails have been constantly increasing since electricity has superseded horses as motive power on street railroads. The rail probably now most used is the ninety pound, nine-inch girder-rail, which is deep enough to allow ballast and paving over the ties. The custom of leaving a small space between rails to allow for expansion is no longer followed, but the ends are cleaned with care and laid closely together. The rails are fastened together by plates about thirty-six inches long, as shown in Fig. 53, having twelve oneinch holes. The bolts should be oiled and very firmly screwed into place, since the joint is the vulnerable point of the track. Continuous rails, made by welding after they have been laid, have been tried with considerable success, the riding qualities have been improved, and the cost of repairs lessened. seems little doubt but this will be the practice in the future. The rails are tied together by rods every five feet, and the gauge should be kept perfect by testing at each tie as the spikes are being driven.

After the rails are spiked the final alignment and grade should be given, and the rails shifted accordingly; the tamping may be done with gravel or with broken stone, the latter material being more durable. The rails on tangent should be made the same height transversely, to prevent a rocking motion f the car, and any final error, in this respect, of more than a

hundredth of a foot should be corrected; after the bonding has been completed the remainder of the ballast is put in place and rammed or rolled till it is compact, when the paving may be begun.

The form as well as the weight of the rail is to be considered, both for its effect upon the paving of the street and as a tramway for vehicles. In order to preserve the surface of

adjacent pavement, it is important that the lower flange shall not interfere with the proper setting of the pavingblocks; this is properly accomplished by using a deep rail, as shown in Fig. 54, where the lower edge of the block is above the lower flange, and there is no necessity for the bad but common



F16. 54.

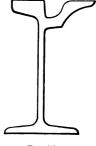
practice of chipping the corner next to the rail, as illustrated in Fig. 55. This arrangement causes the stone to be easily

tipped over or forced down further than the rest, owing to the wedge shape. When a rail is selected that is of less depth than the paving-blocks, the upper and lower flanges should be of nearly equal width, so that a



square block will touch both. In the case of asphalt pavement a T rail is quite satisfactory; the asphalt is laid close up to both sides of the rail. and before it is completely set a car is run over the track, which makes a groove of just the proper size.

The best form for the upper flange of the rail is a subject of debate, but main points are three in number: that form may be adopted that allows carriagewheels to enter and leave the grooves with little danger of injury, as in Fig. 56;



Frg. 56.

or the groove may be of more nearly perpendicular sides, but so narrow that no ordinary tire will enter it, as shown ir Fig. 57; again, the design may be such that it will not acce

modate vehicles at all, as is the case with the tee rail. These

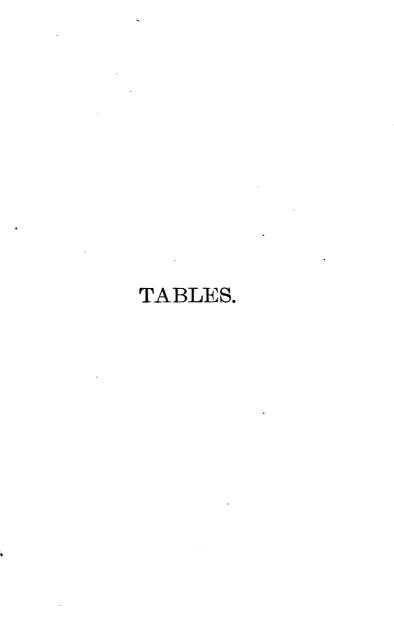


are three examples of common practice, and the best for any particular case will be determined by local considerations.

Prob. 47. Read articles on General Track Construction in the Street Railway Journal for October 1895, page 664; November 1895, page 736; and December 1895, page 803; also November 1896, page 697. Write an abstract of each paper.

Prob. 48. State briefly the arguments in favor of suspended rail joints.

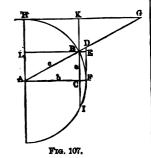
Prob. 49. Make a brief summary of paper and discussion of "Influence of Rails on Pavements," in *Trans. Am. Soc. C. E.*, vol. XXXVII.



TRIGONOMETRIC FUNCTIONS.

Let A (Fig. 107) = angle BAC = arc BF, and let the radius AF = AB = AH = 1.

We then have



In the right-angled triangle ABC (Fig. 107) Let AB = c, AC = b, and BC = a. We then have:

$$1. \sin A = \frac{a}{c} = \cos B$$

$$2. \cos A = \frac{b}{c} = \sin B$$

8.
$$\tan A = \frac{a}{b} = \cot B$$

$$4. \cot A = \frac{b}{a} = \tan B$$

5.
$$\sec A = \frac{c}{b} = \csc B$$

6. cosec
$$A = \frac{c}{a} = \sec B$$

7. vers
$$A = \frac{c-b}{c} = \text{covers } B$$

8. exsec
$$A = \frac{c - b}{b} = \text{coexsec } B$$

9. covers
$$A = \frac{c - a}{c} = \text{versin } B$$

10.
$$\operatorname{coexsec} A = \frac{c - a}{a} = \operatorname{exsec} B$$

11.
$$a = c \sin A = b \tan A$$

12.
$$b = c \cos A = a \cot A$$

13.
$$c = \frac{a}{\sin A} = \frac{b}{\cos A}$$

14.
$$a = c \cos B = b \cot B$$

15.
$$b = c \sin B = a \tan B$$

16.
$$c = \frac{a}{\cos B} = \frac{b}{\sin B}$$

17.
$$a = \sqrt{(c+b)(c-b)}$$

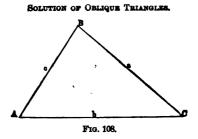
18.
$$b = \sqrt{(c+a)(c-a)}.$$

19.
$$c = \sqrt{a^2 + b^2}$$

20.
$$C = 90^{\circ} = A + B$$

21. area =
$$\frac{ab}{2}$$

TABLE I.—TRIGONOMETRIC FORMULÆ.



	GIVEN.	SOUGHT.	FORMULE.
22	A, B, a	C, b, c	$C = 180^{\circ} - (A + B), \qquad b = \frac{a}{\sin A} \cdot \sin B,$
~	A, a, b	. D. C.	$c = \frac{a}{\sin A} \sin (A + B)$
23	A, a, b	B, C, c	$\sin B = \frac{\sin A}{a} \cdot b, \qquad C = 180^{\circ} - (A + B),$ $c = \frac{a}{\sin A} \cdot \sin C.$
24	C, a, b	14 (A+B)	$\frac{1}{2}(A+B) = 90^{\circ} - \frac{1}{2}C$
25		$\frac{1}{6}(A-B)$	$\tan \frac{1}{2}(A-B) = \frac{a-b}{a+b} \tan \frac{1}{2}(A+B)$
26		A, B	$A = \frac{1}{2}(A + B) + \frac{1}{2}(A - B),$ $B = \frac{1}{2}(A + B) - \frac{1}{2}(A - B)$
27		o	$c = (a+b)\frac{\cos \frac{1}{2}(A+B)}{\cos \frac{1}{2}(A-B)} = (a-b)\frac{\sin \frac{1}{2}(A+B)}{\sin \frac{1}{2}(A-B)}$
28		area	$K = \frac{1}{3}a b \sin C.$
29	a, b, c	A	Let $s = \frac{1}{2}(a+b+c)$; $\sin \frac{1}{2}A = \sqrt{\frac{(s-b)(s-c)}{bc}}$
80			$\cos \frac{1}{2}A = \sqrt{\frac{s(s-a)}{bc}}; \tan \frac{1}{2}A = \sqrt{\frac{(s-b)(s-c)}{s(s-a)}}$
81			$\sin A = \frac{2\sqrt{s}(s-a)(s-b)(s-c)}{bc};$
			$\operatorname{vers} A = \frac{2(s-b)(s-c)}{bc}$
82		area	$K = \sqrt{s(s-a)(s-b)(s-c)}$
88	A, B, C, a	area	$K = \frac{a^2 \sin B \cdot \sin C}{2 \sin A}$

TABLE I .- TRIGONOMETRIC FORMULÆ.

GENERAL FORMULÆ,

$$\sin A = \frac{1}{\csc A} = \sqrt{1 - \cos^2 A} = \tan A \cos A$$

$$35 \quad \sin A = 2 \sin \frac{1}{2} A \cos \frac{1}{2} A = \text{vers } A \cot \frac{1}{2} A$$

$$86 \sin A = \sqrt{\frac{1}{16} \operatorname{vers} 2A} = \sqrt{\frac{1}{16} (1 - \cos 2A)}$$

$$87 \cos A = \frac{1}{\sec A} = \sqrt{1 - \sin^3 A} = \cot A \sin A$$

$$88 \cos A = 1 - \text{vers } A = 2\cos^2 \frac{1}{2}A - 1 = 1 - 2\sin^2 \frac{1}{2}A$$

29
$$\cos A = \cos^2 \frac{1}{2} A - \sin^2 \frac{1}{2} A = \sqrt{\frac{1}{2} + \frac{1}{2} \cos \frac{3}{2} A}$$

$$40 \quad \tan A = \frac{1}{\cot A} = \frac{\sin A}{\cos A} = \sqrt{\sec^2 A - 1}$$

41
$$\tan A = \sqrt{\frac{1}{\cos^3 A} - 1} = \frac{\sqrt{1 - \cos^3 A}}{\cos A} = \frac{\sin 2A}{1 + \cos 2A}$$

$$42 \quad \tan A = \frac{1 - \cos 2 A}{\sin 2 A} = \frac{\text{vers } 2A}{\sin 2 A} = \text{exsec } A \cot \frac{1}{2} A$$

48
$$\cot A = \frac{1}{\tan A} = \frac{\cos A}{\sin A} = \sqrt{\csc^2 A - 1}$$

44
$$\cot A = \frac{\sin 2A}{1 - \cos 2A} = \frac{\sin 2A}{\text{vers } 2A} = \frac{1 + \cos 2A}{\sin 2A}$$

$$45 \quad \cot A = \frac{\tan \frac{1}{2}A}{\operatorname{exsec} A}$$

46 vers
$$A = 1 - \cos A = \sin A \tan \frac{1}{2} A = 2 \sin^2 \frac{1}{2} A$$

47
$$\operatorname{vers} A = \operatorname{exsec} A \cos A$$

48 exsec
$$A = \sec A - 1 = \tan A \tan \frac{1}{2}A = \frac{\text{vers } A}{\cos A}$$

$$49 \quad \sin \frac{1}{2}A = \sqrt{\frac{1-\cos A}{2}} = \sqrt{\frac{\operatorname{vers} A}{2}}$$

$$50 \quad \sin 2A = 2 \sin A \cos A$$

TABLE I.—TRIGONOMETRIC FORMULÆ.

GENERAL FORMULE.

53.
$$\tan \frac{A}{1 + \sec A} = \csc A - \cot A = \frac{1 - \cos A}{\sin A} = \sqrt{\frac{1 - \cos A}{1 + \cos A}}$$

54.
$$\tan 2 A = \frac{2 \tan A}{1 - \tan^2 A}$$

55. cot.
$$\frac{1}{2}A = \frac{\sin A}{\text{vers } A} = \frac{1 + \cos A}{\sin A} = \frac{1}{\cos \cot A - \cot A}$$

56.
$$\cot 2 A = \frac{\cot^2 A - 1}{2 \cot A}$$

57.
$$\operatorname{vers} \frac{1}{1} = \frac{\frac{1}{1} \operatorname{vers} A}{1 + \frac{1}{1} - \frac{1}{1} \operatorname{vers} A} = \frac{1 - \cos A}{2 + \frac{1}{2} (1 + \cos A)}$$

58. vers
$$2 A = 2 \sin^2 A = 2 \sin A \cos A \tan A$$

59. exsec
$$\frac{1}{4}A = \frac{1 - \cos A}{(1 + \cos A) + \frac{1}{2}(1 + \cos A)}$$

60. exsec 2
$$A = \frac{2 \tan^2 A}{1 - \tan^2 A}$$

61,
$$\sin (A \pm B) = \sin A \cdot \cos B \pm \sin B \cdot \cos A$$

62.
$$\cos(A \pm B) = \cos A \cdot \cos B \mp \sin A \cdot \sin B$$

68.
$$\sin A + \sin B = 2 \sin \frac{1}{2} (A + B) \cos \frac{1}{2} (A - B)$$

64.
$$\sin A - \sin B = 2 \cos \frac{1}{2} (A + B) \sin \frac{1}{2} (A - B)$$

65.
$$\cos A + \cos B = 2 \cos \frac{1}{2} (A + B) \cos \frac{1}{2} (A - B)$$

66.
$$\cos B - \cos A = 2 \sin \frac{1}{2} (A + B) \sin \frac{1}{2} (A - B)$$

67.
$$\sin^2 A - \sin^2 B = \cos^2 B - \cos^2 A = \sin (A + B) \sin (A - B)$$

68.
$$\cos^2 A - \sin^2 B = \cos (A + B) \cos (A - B)$$

69.
$$\tan A + \tan B = \frac{\sin (A+B)}{\cos A \cdot \cos B}$$

70.
$$\tan A - \tan B = \frac{\sin (A - B)}{\cos A \cdot \cos B}$$

	0°	1°	2°	1 8°	4°	
'	Sine Cosin	Sine Cosin	Sine Cosin	Sine Cosin	Sine Cosin	'
70	.00000 One.	.01745 .99985	.03490 .99939	.05234 .99863	.06976 .99756	60
1	.00029 One.	.01774 .99984	.03519 .99938	.05263 .99861	.07005 .99754	59
2 8	.00058 One. .00087 One.	.01803 .99984	.03548 .99937	.05292 .99860 .05321 .99858	.07034 .99752 .07063 .99750	58
4	.00116 One.	.01862 .99983	.03606 .99935	.05350 .99857	.07092 .99748	56
5	.00145 One.	.01891 .99982	.03635 .99934	.05379 .99855	.07121 .99746	55
6	.00175 One.	.01920 .99982	.03664 .99933 .03693 .99932	.05408 .99854	.07150 .99744 .07179 .99742	54 53
8	.00204 One.	.01978 .99980	.03723 .99931	.05466 .99851	.07208 .99740	52
9	.00262 One.	.02007 .99980	.03752 .99930	.05495 .99849	.07237 .99738	51
10	.00291 One.	.02036 .99979	.03781 .99929	.05524 .99847	.07266 .99736	50
11	.00320 .99999	.02065 .99979	.03810 .99927	.05553 .99846	.07295 .99734	49
12	.00349 .99999 .00378 .99999	.02094 .99978 .02128 .99977	.03839 .99926 .03868 .99925	.05582 .99844	.07324 .99731	48 47
18 14	.00407 .99999	.02152 .99977	.03897 .99924	.05640 .99841	.07353 .99729 .07382 .99727	46
15	.00436 .99999	.02181 .99976	.03926 .99923	.05669 .99839	.07411 .99725	45
16	.00465 .99999	.02211 .99976	.03955 .99922	.05698 .99838	.07440 .99723	44
17	.00495 .99999 .00524 .99999	.02240 .99975	.03984 .99921 .04013 .99919	.05727 .99836 .05756 .99834	.07469 .99721 .07498 .99719	43 42
19	.00553 .99998	.02298 .99974	.04042 .99918	.05785 .99833	.07527 .99716	41
20	.00582 .99998	.02327 .99973	.04071 .99917	.05814 .99831	.07556 .99714	40
21	.00611 .99998	.02356 .99972	.04100 .99916	.05944 .99829	.07585 .99712	39
22	.00640 .99998	.02385 .99972	.04129 .99915	.05873 .99827	.07614 ,99710	38
23	.00669 .99998 .00698 .99998	.02414 .99971 .02443 .99970	.04159 .99913 .04188 .99912	.05902 .99826 .05931 .99824	.07643 .99708	37 36
25	.00727 .99997	.02472 .99969	.04217 .99911	.05960 .99822	.07701 .99703	85
26	.00756 .99997	.02501 .99969	.04246 .99910	.05989 .99821	.07730 .99701	84
27	.00785 .99997	.02530 .99968	.04275 .99909	.06018 .99819	.07759 .99699	83 82
28	.00814 .99997	.02560 .99967 .02589 .99966	.04304 .99907	.06047 .99817 .06076 .99815	.07788 .99696	81
30	.00873 .99996	.02618 .99966	.04362 .99905	.06105 .99813	.07846 .99692	80
81	.00902 .99996	.02647 .99965	.04391 .99904	.06184 .99812	.07875 .99689	29
32	.00931 .99996	.02676 .99964	.04420 .99902	.06163 .99810	.07904 .99687	28
83	.00960 .99995	.02705 .99963	.04449 .99901	.06192 .99808	.07933 .99685	27
84	.00989 .99995	.02734 .99963 .02763 .99962	.04478 .99900 .04507 .99898	.06221 .99806	.07962 .99683	26 25
86	.01047 .99995	.02792 .99961	.04536 .99897	.06279 .99803	.08020 .99678	24
87	.01076 .99994	.02821 .99960	.04565 .99896	.06308 .99801	.08049 .99676	23
88	.01105 .99994 .01134 .99994	.02850 .99959	.04594 .99894 .04623 .99893	.06337 .99799	.08078 .99673 .08107 .99671	22 21
40	.01164 .99993	.02908 .99958	.04653 .99892	.06395 .99795	.08136 .99668	20
41	.01193 .99993	.02938 .99957	.04682 .99890	.06424 .99793	.08165 .99666	19
42	.01222 .99993	.02967 .99956	.04711 .99889	.06458 .99792	.08194 .99664	18
43	.01251 .99992	.02996 .99955	.04740 .99888	.06482 .99790	.08223 .99661	17
44	.01280 .99992	.03025 .99954	.04769 .99886	.06511 .99788	.08252 .99659	16
45	.01309 .99991 .01338 .99991	.03054 .99953 .03083 .99952	.04798 .99885	.06540 .99786 .06569 .99784	.08281 .99657 .08310 .99654	15 14
47	.01367 .99991	.03112 .99952	.04856 .99882	.06598 .99782	.08339 .99652	13
48	.01396 .99990	.03141 .99951	.04885 .99881	.06627 .99780	.08368 .99649	12
49 50	.01425 .99990	.03170 .99950 .03199 .99949	.04914 .99879 .04943 .99878	.06656 .99778 .06685 .99776	.08397 .99647	11 10
1			11			
51 52	.01483 .99989 .01513 .99989	.03228 .99948 .03257 .99947	.04972 .99878 .05001 .99875	.06714 .99774	.08455 .99642	8
53	.01542 .99988	.03286 .99946	.05030 .99873	.06773 .99770	.08513 .99637	7
54	.01571 .99988	.03316 .99945	.05059 .99872	.06802 .99768	.08542 .99635	6
55 56	.01600+.99987 .01629 .99987	.03345 .99944	.05088 .99870 .05117 .99869	.06831 .99766	.08571 .99632	5
57	.01629 .99987	.03403 .99942	.05117 .99869 .05146 .99867	.06889 .99762	.08629 .99627	8
58	.01687 .99986	.03432 .99941	.05175 .99866	.06918 .99760	.08658 .99625	2
59	.01716 .99985	.03461 .99940	.05205 .99864	.06947 .99758	.08687 .99622	1
60	.01745 .99985	.03490 .99939	.05234 .99863	.06976 .99756	.08716 .99619	0
١,	Cosin Sine	Cosin Sine	Cosin Sine	Cosin Sine	Cosin Sine	١,
	89°	88°	87*	86°	85°	
_	1 65- (1 66-)			- -		

	1 5° il 6° i							. 00			
	5°				7		!	•	8	0	,
-	10	Cosin	Sine	Cosin	Sine	Cosin	Sine	Cosin	Sine	Cosin	_
0	.08716 . .08745 .	99619 99617	.10458 .10482	.99452 .99449	.12187 .12216	.99255	.13917	.99027	.15643 .15672	.98769 .98764	60 59
2	.08774 .	99614	.10511	.99446	.12245	.99248	.13975	.99019	.15701	.98760	58
8		99612 99609	.10540	.99443 .99440	.12274	.99244	.14004	.99015 .99011	.15730 .15758	.98755	57 56
5	.08860 .	99607	.10597	.99437	.12331	.99237	.14061	.99006	.15787	.98746	55
6		99604 99602	.10626 .10655	.99434 .99431	.12360	.99233	.14090 .14119	.99002	.15816 .15845	.98741	54 53
8	.08947	99599	.10684	.99428	.12418	.99226	.14148	.98994	.15873	.98732	52
10		99596 99594	.10713	.99424	.12447	.99222	.14177	.98990	.15902	.98728	51
11	1	99591	.10771	.99421	.12476	.99219	.14205	.98986	.15931	.98723	50 49
12		99588	.10800	.99418	.12504 .12533	.99215 .99211	.14234 .14263	.98982 .98978	.15959 .15988	.98718 .98714	49
18	.09092 .	99586	.10829	.99412	,12562	.99208	.14292	.98973	.16017	.98709	47
14 15		99583 99580	.10858	.99409	.12591 .12620	.99204	.14320 .14349	.98969 .98965	1.16046 .16074	.98704	46 45
16	.09179 .	99578	.10916	.99402	.12649	.99197	.14378	.98961	. 16103	.98695	44
17		99575 99572	.10945	.99399 .99396	.12678	.99193	.14407	.98957	.16132	.98690	43 42
19	.09266 .	99570	.11002	.99393	.12706 .12735	.99189 .99186	.14436	.98953	.16160 .16189	.98681	42
. 20	1	99567	.11031	.99390	.12764	.99182	.14493	.98944	.16218	.98676	40
21		99564	.11060	.99386	.12793	.99178	.14522	.98940	.16246	.98671	89
22 23		99562 99559	.11089	.99383	.12822	.99175 .99171	.14551 .14580	.98936 .98931	.16275 .16304	.98667 .98662	38 37
24	.09411	99556	.11147	.99377	.12851 .12880	.99167	.14608	.98927	.16333	.98657	36
25 26	.09440 .	99553 99551	.11176 .11205	.99374	.12908 .12937	.99163 .99160	.14637 .14666	.98923	.16361 .16390	.98652 .98648	35 34
27 28	.09498 .	99548	.11234	.99367	.12966	.99156	.14695	.98914	.16419	.98643	33
28		99545	.11263	.99364	.12995	.99152	.14723	.98910	.16447	.98638	32
29 30		99542 99540	.11291	.99360 .99357	.13024	.99148	.14752 .14781	.98906	.16476 .16505	.98633 .98629	81 30
81		99537	.11349	.99354	.13081	.99141	.14810	.98897	.16533	.98624	29
82		99534	.11378	.99351	.13110	.99137	.14838	.98893	.16562	.98619	28 27
84	.09700	99531 99528	.11407 .11436	.99347 .99344	.13139	.99133	.14867 .14896	.98889 .98884	.16591 .16620	.98614 .98609	26 25
35	.09729	99526	.11465	.99341	.13197	.99125	.14925	.98880	.16648	.98604	25
36 37		99523 99520	.11494 .11523	.99337	.13226 .13254	.99122 .99118	.14954 .14982	.98876 .98871	.16677 .16706	.98600 .98595	24 23
38	.09816	99517	.11552	.99331	.13283	.99114	.15011	.98867	.16734	.98590	22
39 40		99514 99511	.11580 .11609	.99327 .99324	.13312 .13341	.99110 .99106	.15040 .15069	.98863 .98858	.16763 .16792	.98585 .98580	24 22 22 22 22 22 22 22 22 22 22 22 22 2
41	1	99508	.11638	.99320	.13370	.99100	.15009	.98854	.16820	.98575	19
42	.09932 .	99506	.11667	.99317	.13399	.99098	.15126	.98849	.16849	.98570	18
43 44	.09961 .	99503	.11696	.99314	.13427	.99094	.15155	.98845 .98841	.16878	.98565 .98561	17 16
44		99500 99497	.11725 .11754	.99310 ·99307	.13456 .13485	.99091 .99087	.15184 .15212	.98836	.16906 .16935	.98556	15
46	.10048	99494	.11783	.99303	.13514	.99083	.15241	.98832	.16964	.98551	14
47		99491 99488	.11812	.99300 .99297	.13543 .13572	.99079	.15270 .15299	.98827 .98823	.16992 .17021	.98546 .98541	18 12
49	.10135 .	99485	.11869	.99293	.13600	.99071	.15327	.98818	.17050	.98536	11
50		99482	.11898	.99290	.13629	.99067	.15356	.98814	.17078	.98531	10
51 52		99479 99476	.11927 .11956	.99286	.13658 .13687	.99063	.15385 .15414	.98809 .98805	.17107 .17136	.98526 .98521	9
53	.10250 .	99478	.11985	.99279	.13716	.99055	.15442	.98800	.17164	.98516	8
54 55		99470	.12014	.99276	.13744	.99051	.15471	.98796 .98791	.17193 .17222	.98511 .98506	6
56		99467 99464	.12043	.99272 .99269	.13773	.99047 .99043	.15500 .15529	98787	.17250	.98501	4
57	10366 .	99461	.12100	.99265	. 13831	.99039	.15557	.98782	.17279	.98496	4 8 2 1 0
58 59		99458 99455	.12129 .12158	.99262	.13860 .13889	.99035 .99031	.15586 .15615	.98778 .98773	.17308 .17336	.98491 .98486	1
60	.10458 .	99452	.12187	.99255	.13917	.99027	.15643	.98769	.17365	.98481	Õ
,	Cosin	Sine	Cosin	Sine	Cosin	Sine	Cosin	Sine	Cosin	Sine	,
	84	•	8	3•	89	3.	81		80)•	-

	10°	11°	12°	13°	14°	
1'	Sine Cosin	Sine Cosin	Sine Cosin	Sine Cosin	Sine Cosin	,
0	.17365 .98481	.19081 .98163	.20791 .97815	.22495 .97437	.24192 .97030	60
ĭ	.17393 .98476	.19109 .98157	.20820 .97809	.22523 .97430	.24220 .97023	59
2	.17422 .98471	.19138 .98152	.20848 .97803	.22552 .97424	.24249 .97015	58
8	.17451 .98466 .17479 .98461	.19167 .98146 .19195 .98140	.20877 .97797 .20905 .97791	.22580 .97417 .22608 .97411	.24277 .97008 .24305 .97001	57
4	.17479 .98461 .17508 .98455	.19224 .98135	.20933 .97784	.22637 .97404	.24383 .96994	56 55
6	.17537 .98450	.19252 .98129	.20962 .97778	.22665 497398	.24362 .96987	54
7	.17565 .98445	.19281 .98124	.20990 .97772	.22693 .97391	.24390 .96980	58
8	.17594 .98440 .17623 .98435	.19309 .98118 .19338 .98112	.21019 .97766 .21047 .97760	.22722 .97384 .22750 .97378	.24418 .96973	52
9 10	.17623 .98435 .17651 .98430	.19366 .98107	.21076 .97754	.22778 .97371	.24446 .96966 .24474 .96959	51 50
11	.17680 .98425	.19895 .98101	.21104 .97748	.22807 .97865	.24503 .96952	49
12	.17708 .98420	.19423 .98096	.21132 .97742	.22835 .97358	.24531 .96945	48
18	.17787 .98414	.19452 .98090	.21161 .97785	.22863 .97351	.24559 .96937	47
14 15	.17766 .98409 .17794 .98404	.19481 .98084 .19509 .98079	.21189 .97729 .21218 .97723	.22892 .97345 .22920 .97838	.24587 .96930 .24615 .96928	46 45
16	.17823 .98399	.19538 .98073	.21246 .97717	.22948 .97881	.24644 .96916	44
17	.17852 .98394	.19566 .98067	.21275 .97711	.22977 .97325	.24672 .96909	43
18	.17880 .98389	.19595 .98061	.21303 .97705	.23005 .97818	.24700 .96902	42
19 20	.17909 .98383 .17937 .98378	.19623 .98056 .19652 .98050	.21331 .97698 .21360 .97692	.23033 .97311 .23062 .97304	.24728 .96894 .24756 .96887	41 40
21	.17966 .98373	.19680 .98044	.21388 .97686	.23090 .97298	.24784 .96880	89
22	.17995 .98368	.19709 .98039	.21417 .97680	.23118 .97291	.24813 .96873	38
23	.18023 .98362	.19737 .98033	.21445 .97673	.23146 .97284	.24841 .96866	37
24	.18052 .98857	.19766 .98027	.21474 .97667	.23175 .97278	.24869 .96858	86
25 26	.18081 .98352 .18109 .98347	.19794 .98021	.21502 .97661 .21530 .97653	.23203 .97271 .23231 .97264	.24897 .96851 .24925 .96844	85 84
27	.18109 .98347 .18188 .98341	.19823 .98016 .19851 .98010	.21530 .97653 .21559 .97648	23260 97257	.24954 .96837	99
28	.18166 .98336	.19880 .98004	.21587 .97642	.23288 .97251	.24982 .96829	83 82
29	.18195 .98331	.19908 . 979 98	.21616 .97636	.23316 .97244	.25010 .96822	81
80	.18224 .98325	.19987 .97992	.21644 .97630	.23345 .97287	.25088 .96815	80
81 82	.18252 .98320 .18281 .98315	.19965 .97987 .19994 .97981	.21672 .97623 .21701 .97617	.23373 .97280 .23401 .97223	.25066 .96807 .25094 .96800	29 28
33	.18809 .98310	.20022 .97975	.21729 .97611	.23429 .97217	.25122 .96793	27
84	.18338 .98304	.20051 .97969	.21758 .97604	.23458 .97210	.25151 .96786	26
85	.18867 .98299	.20079 .97963	.21786 .97598	.23486 .97203	.25179 .96778	25
86 87	.18895 .98294 .18424 .98288	.20108 .97958	.21814 .97592 .21843 .97585	.23514 .97196 .23542 .97189	.25207 .96771 .25285 .96764	24
88	.18452 .98283	.20165 .97946	.21871 .97579	.23571 .97182	.25285 .96764 .25263 .96756	23 22
89	.18481 .98277	.20193 .97940	.21899 .97573	.23599 .97176	.25291 .96749	21
40	.18509 .98272	.20222 .97934	.21928 .97566	.23627 .97169	.25820 .96742	3 0
41	.18538 .98267	.20250 .97928	.21956 .97560	.28656 .97162	.25348 .96734	19
42 43	.18567 .98261 .18595 .98256	.20279 .97922	.21985 .97553 .22013 .97547	.23684 .97155 .23712 .97148	.25376 .96727 .25404 .96719	18 17
44	.18624 .98250	.20336 .97910	.22013 .97541	.23740 .97141	.25432 .96712	16
45	.18652 .98245	.20364 .97905	.22070 .97534	.23769 .97184	.25460 .96705	15
46	.18681 .98240	.20393 .97899	.22098 .97528	.23797 .97127	.25488 .96697	14
47 48	.18710 .98234 .18738 .98229	.20421 .97893 .20450 .97887	.22126 .97521 .22155 .97515	.23825 .97120 .23853 .97118	.25516 .96690 .25545 .96682	13 12
49	.18767 .98223	.20478 .97881	.22155 .97515 .22183 .97508	.23853 .97118 .23882 .97106	.25573 .96675	11
50	.18795 .98218	.20507 .97875	.22212 .97502	.23910 .97100	.25601 .96667	10
51	.18824 .98212	.20585 .97869	.22240 .97496	.23938 .97093	.25629 .96660	9
58	.18852 .98207 .18881 .98201	.20563 .97863 .20592 .97857	.22268 .97489 .22297 .97483	.23966 .97086	.25657 .96653 .25685 .96645	8
54	.18910 .98196	.20620 .97851	.22325 .97476	.24023 .97072	.25713 .96638	6
55	.18988 .98190	.20649 .97845	.22353 .97470	.24051 .97065	.25741 .96630	5
56	.18967 .98185	.20677 .97839	.22382 .97463	.24079 .97058	.25769 .96623	4
57	.18995 .98179	.20706 .97833	.22410 .97457	.24108 .97051	.25798 .96615 .25826 .96608	8
58 59	.19024 .98174 .19052 .98168	.20784 .97827 .20763 .97821	.22438 .97450	.24186 .97044 .24164 .97087	.25826 .96608 .25854 .96600	2
60	.19081 .98163	.20791 .97815	.22495 .97437	.24192 .97030	.25882 .96593	ō
7	Cosin Sine	Cosin Sine	Cosin Sine	Cosin Sine	Cosin Sine	_
	79°	78°	77°	76°	75°	

TABLE II.—NATURAL SINES AND COSINES.

	15°		16°		1	17*		18°		19°	
1'	Sine	Cosin	Sine	Cosin	Sine	Cosin	Sine	Cosin	Sine	Cosin	
10	.25882	.96593	.27564	.96196	.99287	.95690	.80000	.96106	.82557	.94552	60
1 2	.25910	.96585	.27592	.96118 .96110	.29265	.95622	.30929 .30957	.95097 .95088	.82584 .82619	.94542	59 58
8	.25966	.96570	.27648	.96102	.29321	.95605	.30985	.95079	.82639	.94523	57
4	.25994	.96562	.27676	.96094	.29348	.95596	.81012	.95070	.82667	.94514	56
5	.26022	.96555	.27704 .27731	.96096 .96078	.29376	.95588	.81040 .81068	.95061	.82694 .82722	.94504 .94495	55 54
7	.26079	.96540	.27759	96070	.29432	.95571	.81095	.95048	.82749	.94485	58
8	.26107	.96582	.27787	.96062	.29460	.95562	.81128	.95083	.82777	.94476	52 51
10	.26135 .26168	.96524 .96517	.27815 .27843	.96054 .96046	.29487 .29515	.95545	.31151 .81178	.95024	.82832	.94466 .94457	50
11	.26191	.96509	.27871	.96087	.29548	.95586	.81206	.95006	.82859	.94447	49
12	.26219	.96502	.27899 .27927	.96029	.29571 .29599	.95528 .95519	.81238 .81261	.94997	.82887 .82914	.94438	48
18	.26247	.96486	.27955	.96021	.29626	.95511	.81289	.94979	.82942	.94418	
15	.26303	.96479	.27983	.96005	.29654	.95502	.81816	.94970	.82969	.94409	45
16	.26331	.96471	.28011	.95997 .95989	.29682 .29710	.95493	.81844 .81872	.94961 .94952	.82997	.94399	44
17	.26387	.96456	.28067	.95981	.29710	.95476	.31372	.94948	.88051	.94380	42
19	.26415	.96448	.28095	.95972	.29765	.95467	.81427	.94988	.83079	.94870	41
20	.26443	.96440	.28128	.95964 05056	.29798	.95459	.81454	.94994	88106	.94361	40 39
21 22	.26471 .26500	.96483	.28150 .28178	.95956	.29821 .29849	.95450 .95441	.81482 .81510	.94915 .94906	.38184 .88161	.94351 .94342	
28	.26528	.96417	.28206	.95940	.29876	. 95433	.81587	.94897	.83189	.94882	87
24	.26556	.96410	.28234	.95931	.29904	.95424	.81565	94888	.88216	.94822	
25 26	.26584 .26612	.96402	.28262	.95923 .95915	.29932		.31593	94878	.88244	.94818	84
27	.26640	.96886	.28318	.95907	.29987	.95398	.81648	.94560	.83298	.94293	88
28	.26668	.96379	.28346	.95898	.80015		.81675	.94851	.88896	.94984	82
29 30	.26696 .26724	.96371 .96363	.28374 .28402	.95890 .95882	.80043 .80071		.81703 .81780	.94842 .94882	.88858 .88881	.94274 .94264	81 80
81 32	.26752 .26780	.96855 .96847	.28429 .28457	.95874 .95865	.80098 .80126		.81758 .81786	.94828	. 89408	.94254	29 28
33	.26808	.96340	.28485		.80120	.95345	.81780	.94814	85468	.94245	
84	.26836	.96332	.28518	.95849	.80182	.95887	.81841	.94795	.88490	.94225	26
35 36	.26864	.96324 .96316	.28541	.95841 .95832	.30209	.95328	.81868 .81896	.94786	.88518 .88545	.94215	
37	.26920	.96308	.28597	.95824	.80265	.95310	.81923	.94768	1 .88578	.94196	23
88	.26948	.96301	.28625	.95816	.30292	.95301	81951	.94758	.88600	.94186	22
39 40	.26976 .27004	. 96293 . 96285	.28652 .28680	.95807 .95799	.30320 .30348		.81979 .82006	.94749 .94740	. 88627 . 88655	.94176 .94167	21 20
41	.27032	.96277	.28708	.95791	.80376		.82084	.94780	.33682	.94157	19
42	.27060	.96269	.28736	.95782	.30403	.95266	.82061	.94721	.88710	.94147	18
43	.27088 .27116	.96261	.28764 .28792	.95774 .95766	.30431	.95257	.82089 .82116	.94712	.88737 .88764	.94137 .94127	17 16
45	.27144	.96246	28820	.95757	.80486	.95240	.82144	.94693	.88792	.94118	15
46	27172	.96288	.28847	.95749	.80514	.95231	.82171	.94684	.83819	.94108	14
47	.27200 27228	.96230 .96222	.28875	.95740 .95732	.30542	.95222	.82199 .82227	.94674	.83846	.94098 .94088	18 12
49	.27256	.96214	.28931	.95724	.80597	.95204	.82254	.94656	88901	.94078	11
50	.27284	.96206	.28959	.95715	.80625	.95195	.82282	.9464d	.88929	.94068	10
51 52	.27812 .27340	.96198	.28987	.95707 .95698	.30653	.95186	.82809	.94637 .94627	.83956	.94058 .94049	8
53	.27368	.96182	.29042	.95690	.30708	.95168	.82364	.94618	.84011	.94039	7
54	.27396	.96174	.29070	.95681	.80736	.95159	82892	.94609	.84088	.94029	6
55 56	.27424 .27452	.96166 .96158	.29098 .29126	.95678	.80763 .80791	.95150 .95142	.82419 .82447	.94599 .94590	.84065 .84098	.94019 .94009	5 4
57	.27480	.96150	.29154	.95656	.80819	.95183	.32474	.94580	.84120	.93999	8
58	.27508	.96142	.29182	.95647	.80846	.95124	.82502	.94571	.84147	.98989	2
59 60	.27586 .27564	.96184 .96126	.29209 .29237	.95639 .95630	.30874 .30902	.95115 .95106	.82529 .82557	.94561 .94562	.84175 .84202	.93979 .93969	0
 -	Cosin	Sine	Cosin	Sine	Cosin	Sine	Cosin	Sine	Cosin	Sine	-
	74	!• [73	3°	79	3 0	71	ļ•	70)•	

	20°	21°	22°	23*	24° .	
'	Sine Cosin	Sine Cosin	Sine Cosin	Sine Cosin	Sine Cosin	1
0	.34202 .93969	.35837 .93358	.37461 .92718	.39078 .92050	.40674 .91855	60
1	.34229 .93959	.85864 .93348	.87488 .92707	.89100 .92039	.40700 .91843	59
2 8	.34257 .93949 .34284 .93939	.35891 .93337 .85918 .93327	.87515 .92697 .37542 .92686	.89127 .92028 .89153 .92016	.40727 .91331	58 57
4	.34311 .93929	.35945 .93316	.87569 .92675	.89180 .92005	.40780 .91307	56
5	.34339 .93919	.85973 .93306	.87595 .92664	.89207 .91994	.40806 .91295	55
6	.84366 .93909	.36000 .93295 .36027 .93285	.87622 .92653	.39234 .91982	.40833 .91283	54
8	.34393 .93899 .34421 .93889	.36027 .93285 .36054 .93274	.87649 .92642 .87676 .92631	.39260 .91971 .39287 .91959	.40860 .91272 .40886 .91260	58 52
9.	.34448 .93879	.36081 .93264	.37703 .92620	.39314 .91948	.40913 .91248	51
10	.84475 .93869	.86108 .93258	.87730 .92609	.39341 .91936	.40939 .91236	50
11	.34503 .93859	.86185 .98243	.87757 .92598	.39367 .91925	.40966 .91224	49.
12	.34530 .93849	.86162 .93232	.87784 .92587	.89394 .91914	.40992 .91212	48
13 14	.34557 .93839 .34584 .93829	.36190 .93222 .36217 .93211	.87811 .92576 .87838 .92565	.39421 .91902 .39448 .91891	.41019 .91200 .41045 .91188	47
13	.34612 .93819	.86244 .93201	.87865 .92554	.39474 .91879	.41072 .91176	45
16	.34639 .93809	.36271 .93190	.87892 .92543	.39501 .91868	.41098 .91164	44
17	.34666 .93799	.36298 .93180	.87919 .92532	.39528 .91856	.41125 .91152	43
18	.34694 .93789 .34721 .93779	.36325 .93169 .36352 .93159	.87946 .92521 .87973 .92510	.89555 .91845 .89581 .91833	.41151 .91140 .41178 .91128	42 41
20	.84748 .93769	.36379 .93148	.87999 .92499	.39608 .91822	.41204 .91116	40
21	.34775 .93759	.36406 .98187	.88026 .92488	.39635 .91810	.41231 .91104	39
22	.84803 .93748	.86434 .93127	.88053 .92477	.39661 .91799	.41257 .91092	38
23	.34830 .93738	.86461 .93116	.88080 .92466	.39688 .91787	.41284 .91080	87
24 25	.34857 .93728	.86488 .93106 .86515 .93095	.38107 .92455 .38134 .92444	.89715 .91775	.41310 .91068	36 35
26	.34884 .93718 .84912 .93708	.36515 .93095 .36542 .93084	.38134 .92444 .38161 .92482	.89741 .91764 .39768 .91752	.41387 .91056 .41363 .91044	84
27	.34939 .93698	.86569 .93074	.88188 .92421	.39795 .91741	.41390 .91032	33
28	.34966 .93688	.36596 .93063	.88215 .92410	.89822 .91729	.41416 .91020	82
29	.34993 .93677 .85021 .93667	.36623 .93052 .36650 .93042	.88241 .92399 .88268 .92388	.39848 .91718 .39875 .51706	.41443 .91008 .41469 .90996	31 30
1		1		1 1	1	
81 82	.35048 .93657 .35075 .93647	.86677 .93031 .86704 .93020	.38295 .92377 .38322 .92366	.39902 .91694 .39928 .91683	.41496 .90984 .41522 .90972	29 28
83	.35102 .93637	.36731 .93010	.38349 .92355	.89955 .91671	41549 .90960	27
84	.85130 .93626	.36758 .92999	.38376 .92343	.89982 .91660	.41575 .90948	26
85 86	.35157 .93616 .35184 .93606	.36785 .92988 .36812 .92978	.88403 .92332 .88430 .92321	.40008 .91648 .40035 .91636	.41602 .90936 .41628 .90924	25 24
87	.35184 .93606 .35211 93596	.36839 .92967	.38456 .92310	.40062 .91625	.41655 .90911	23
88	.35239 .93585	.36867 .92956	.38483 .92299	.40088 .91613	.41681 .90899	22
89	.35266 .93575	.36894 .92945	.38510 .92287	.40115 .91601	.41707 .90887	21
40	.35293 .93565	.86921 .92935	.88537 .92276	.40141 .91590	.41784 .90875	20
41	.35320 .98555	.36948 .92924	.38564 .92265	.40168 .91578	.41760 .90863	19
42	.35347 .93544 .35375 .93534	.86975 .92013 .87002 .92902	.38591 .92254 .38617 .92243	.40195 .91566 .40221 .91555	.41787 .90851 .41813 .90839	18 17
44	.35402 .93524	.37029 .92892	.88644 .92231	.40248 .91543	.41840 .90826	16
45	.85429 .93514	.87056 .92881	.38671 .92220	.40275 .91581	.41866 .90814	
46	.35456 .93503 .35484 .93493	.37083 .92870 .37110 .92859	.38698 .92209 .38725 .92198	.40301 .91519 .40328 .91508	.41892 .90802 .41919 .90790	14 18
48	.85511 .93483	.37137 .92849	.38752 .92186	.40355 .91496	.41945 .90778	12
49	.35538 .93472	.87164 .92838	.38778 .92175	.40381 .91484	.41972 .90766	11
50	.35565 .93462	.87191 .92827	.38805 .92164	.40408 .91472	.41998 .90753	10
51	.35592 .93452	.87218 .92816	.38832 .92152	.40434 .91461	.42024 .90741	9
52	.35619 .93441	.87245 .92805	.38859 .92141	.40461 .91449	.42051 .90729	8
58 54	.35647 .93431 .35674 .93420	.87272 .92794 .87299 .92784	.38886 .92130 .38912 .92119	.40488 .91437 .40514 .91425	.42077 .90717 .42104 .90704	.7
55	.35701 .93410	.37326 .92773	.38939 .92107	.40541 .91414	.42130 .90692	5
56	.35728 .93400	.87353 .92762	.38966 .92096	.40567 .91402	.42156 .90680	4
57	.35755 .93389 .35782 .93379	.87380 .92751 .87407 .92740	.38993 .92085	.40594 .91390	.42183 .90668 .42209 .90655	8 2
59	.35782 .93379	.87434 .92729	.39020 .92073 .39046 .92062	.40621 .91378 .40647 .91366	.42235 .90643	1
60	.35837 .93358	.37461 .92718	.39073 .92050	.40674 .91855	.42262 .90631	· ō
-	Cosin Sine	Cosin Sine	Cosin Sine	Cosin Sine	Cosin Sine	- :
′		000			050	′
	69° 68°		67°	66°	65°	

	2	5°	2	B°	2'	7°	2	3°	29)°	
'	Sine	Cosin	Sine	Cosin	Sine	Cosin	Sine	Cosin	Sine	Cosin	′
0	42262	.90631	.43837	.89879	.45399	.89101	46947	.88295	,48481	.87462	60
1 1	.42288	.90618	.43863	.89867	.45425	.89087	46973	.88281	.48506	.87448	59
2	.42315	.90606	.43889	.89854	.45451	.89074	46999	.88267	.48532	.87434 .87420	58
8 4	.42341 .42367	.90594	.43916 .43942	.89841 .89828	.45477	.89061 .89048	47024 47050	.88240	48583	.87406	57 56
5	42394	.90569	.43968	.89816	.45529	.89035	47076	.88226	.48608	.87891	55
6	.42420	.90557	.43994	.89803	.45554	.89021	47101	.88213	.48634	.87877	54
7	.42446	.90545	.44020	.89790	.45580	.89008	47127	.88199	.48059	.87363	58
8	.42473 .42499	.90532	.44046	.89777	.45606 .45632	.88995 .88981	47158 47178	.88185	.48684	.87349 .87335	52 51
10	.42525	.90507	.44098	.89752	.45658	.88968	47204	.88158	.48735	.87321	50
11	.42552	.90495	.44124	.89739	.45684	.88955	47229	.88144	.48761	.87306	49
12	.42578	.90483	.44151	.89726	.45710	.88942	47255	.88130	.48786	.87292	48
13 14	.42604 .42631	.90470 .90458	.44177	.89713 .89700	.45786 .45762		47281 47306	.88117	.48811	.87278 .87264	47 46
15	.42657	.90446	.44229	.89687	.45787	.88902	47332	.88089	.48862	.87250	45
16	.42683	.90433	.44255	.89674	.45813	.88888	47358	.88075	.48888	.87235	44
17	.42709	.90421	.44281	.89662	.45839	.88875	47383	.88062	,48913	.87221	43
18	.42736	.90409	.44307	.89649	.45865	.88862	47409	.88048	.489 38 .489 64	.87207	42 41
19 20	.42762 .42788	.90396	.44333 .44359	.89636 .89623	.45891 .45917	.88848 .88835	47434 47460	.88020	.48989	.87198 .87178	40
		1 1		1 1	.45942	.88822	47486	.88006	.49014	.87164	39
21	.42815 .42841	.90371	.44385 .44411	.89610 .89597	.45942 .45968		47511	.87993	49040	.87150	38
22 23	.42867	.90346	.44437	.89584	.45994	.88795	47537	.87979	.49065	.87136	87
24	.42894	.90334	.44464	.89571	.46020	.88782	47562	.87965	.49090	.87121	86
25	.42920	.90321	.44490	.89558	.46046	.88768	47588	.87951	.49116	.87107	85
26	.42946	.90309	.44516 .44542	.89545 .89532	.46072 .46097	.88755 .88741	47614 47639	.87937	.491 41 .491 66	.87093 .87079	84 99
27 28	.42999	.90284	.44568	.89519	.46123	.88728	47665	.87909	49192	.87064	83 82
29	.43025	.9:271	.44594	.89506	.46149	.88715	47690	.87896	49217	.87050	81
30	.43051	.90259	.44620	.89493	.46175	.88701	.47716	.87882	.49242	.87036	80
81	.43077	.90246	.44646	.89480	.46201	.88688	47741	.87868	,49268 ,49293	.87021 .87007	29
32 33	.43104	.90233	.44672 .44698	.89467 .89454	.46226	.88674 .88661	.47767 .47793	.87854 .87840	.49318	.86993	28 27
34	.43156	.90208	44724		46278	.88647	47818	.87826	.49344	.86978	26
35	.43182	.90196	.44750	.89428	.46304	.88634	.47844	.87812	.49369	.86964	25
36	.43209 .43235	.90183	.44776	.89415	.46330	.88620 .88607	.47869 .47895	.87798 .87784	.49394 .49419	.86949 .86935	24 23
37 38	.43261	.90171	.44802 .44828	.89402 .89389	.46355 .46381	.88593	47920	.87770	49445	.86921	22
39	.43287	.90146	44854	.89376	46407	.88580	47946	.87756	.49470	.86906	21
40	.43313	.90133	.44880	.89363	.46433	.88566	47971	.87743	.49495	.86892	20
41	.43340	.90120	.44906	.89350	.46458	.88553	47997	.87729	.49521	.86878	19
42	.43366	.90103	.44932	.89337	.46484	.88539	48022	,87715	.49546 .49571	.86863 .86849	18 17
43 44	.43392 .43418	.90095	.44958 .44984	.89324 .89311	.46510 .46536	.88526 .88512	48048 48073	.87701	.49571	.86834	16
45	.43445	.90070	.45010	.89298	.46561	.88499	48099	.87673	.49622	.86820	15
46	.43471	.90057	.45036	.89285	.46587	.88485	.48124	.87659	.49647	.86805	14
48	.43497	.90045	.45062	.89272	.46618	.88472	48150	.87645	49672	.86791	13 12
48	.43523 .43549	.90032	.45088 .45114	.89259 .89245	.46639 .46664	.88458 .88445	.48175 .48201	.87631 .87617	.49697	.86777 .86762	11
50	.43575	.90007	.45140	.89232	.46690	.88431	48226	.87603	49748	.86748	10
51	.43602	.89994	.45166	.89219	.46716	.88417	48252	.87589	.49773	.86733	98765
52	.43628	.89981	.45192	.89206	.46742	.88404	48277	.87575	.49798	.86719 .86704	ğ
53 54	.43654	.89968 .89956	.45218 .45243	.89193 .89180	.46767 .46793	.88390 .88377	.48303 .48328	.87561	.49824	.86690	6
55	.43706	.89943	.45269	.89167	.46819	.88363	48354	.87532	49874	.86675	Ď
56	.43733	.89930	.45295	.89153	.46844	.88349	48379	.87518	.49899	.86661	4
57	.43759	.89918	.45321	.89140	.46870	.88336	48405	.87504	49924	.86646	8
58 59	.43785 .43811	.89905 .89892	.45347	.89127 .89114	.46896 .46921	.88322	.48430 .48456	.87490 .87476	.49950	.86632 .86617	2
60	.43837	.89879	.45399	.89101	.46947	.88295	48481	.87462	.50000	.86603	Ô
_	Cosin	Sine	Cosin	Sine	Cosin	Sine	Cosin	Sine	Cosin	Sine	,
	6	40	6	3°	6	2°	61	0	60)°	

ſ .	80°	31•	32•	33° .	34°	
′	Sine Cosin	Sine Cosin	Sine Cosin	Sine Cosin	Sine Cosin	1
70	.50000 .86603	.51504 .85717	.52992 .84805	.54464 .83867		60
1	.50025 .86588	.51529 .85702	.53017 .84789	.54488 .83851	.55943 .82887	59
8	.50050 .86573 .50076 .86559	.51554 .85687 .51579 .85672	.53041 .84774 .53066 .84759	.54513 .83835	.55968 .82871	58
4	.50076 .86559 .50101 .86544	.51579 .85672 .51604 .85657	.53066 .84759 .53091 .84743	.54537 .83819 .54561 .83804		57 56
5	.50126 .86530	.51628 .85642	.53115 .84728	.54586 .83788		55
6	.50151 .86515	.51653 .85627	.53140 .84712	.54610 .83772	.56064 .82806	54
7	.50176 .86501 .50201 .86486	.51678 .85612	.53164 .84697	.54635 .83756	.56088 .82790	53
8	.50201 .86486 .50227 .86471	.51703 .85597 .51728 .85582	.53189 .84681 .53214 .84666	.54659 .83740 .54683 .83724		52 51
10	.50252 .86457	.51753 .85567	.53238 .84650	.54708 .837.8		50
11	.50277 .86442	.51778 .85551	.53263 .84635	.54732 .83692		49
12	.50302 .86427	.51803 .85536	.53288 .84619	.54756 .83676	.56208 .82708	48
13 14	.50327 .86413 .50352 .86398	.51828 .85521 .51852 .85506	.53312 .84604 .53337 .84588	.54781 .83660 .54805 .83645		47 46
15	.50377 .86384	.51877 .85491	.53361 .84573	.54829 .83629		45
16	.50403 .86369	.51902 .85476	.53386 .84557	.54854 .83613	.56305 .82643	44
17	.50428 .86354	.51927 .85461	.53411 .84542	.54878 .83597	.56329 .82626	48
18 19	.50453 .86340 .50478 .86325	.51952 .85446 .51977 .85431	.53435 .84526	.54902 .83581	.56853 .82610	42
20	.50508 .86310	.52002 .85416	.53460 .84511 .58484 .84495	.!.4927 .83565 .54951 .83549	.56877 .82598 .56401 .82577	41 40
21	.50528 .86295	.52026 .85401	.53509 .84480	.54975 .83533		39
22	.50553 .86281	.52051 .85385	.53534 .84464	.54999 .83517	.56449 .82544	38
23 24	.50578 .86266 .50603 .86251	.52076 .85370 .52101 .85355	.53558 .84448	.55024 .83501	.56473 .82528	37
25	.50628 .86237	.52101 .85355 .52126 .85340	.53583 .84433	.55048 .88485 .55072 .88469	.56497 .82511 .56521 .82495	36 35
26	.50654 .86222	.52151 .85325	.53632 .84402	.55097 .83453	.56545 .82478	34
27	.50679 .86207	.52175 .85310	.53656 .84386	.55121 .83437	.56569 .82462	33 32
28	.50704 .86192	.52200 .85294	.53681 .84370	.55145 .88421	.56593 .82446	32
29 30	.50729 .86178 .50754 .86163	.52225 .85279 .52250 .85264	.53705 .84355 .53730 .84339	.55169 .83405 .55194 .83389	.56617 .82429 .56641 .82413	31 30
81	.50779 .86148	.52275 .85249	.53754 .84324	.55218 .83378		29
32 33	.50804 .86133 .50829 .86119	.52299 .85234 .52324 .85218	.53779 .84308	.55242 .83356	.56689 .82380	28 27
34	.50829 .86119 .50854 .86104	.52324 .85218 .52349 .85203	.53804 .84292 .53828 .84277	.55266 .83340 .55291 .83324	.56718 .82363 .56736 .82347	26
85	.50879 .86089	.52374 .85188	.53853 .84261	.55315 .83308	.56760 .82380	25
86	.50904 .86074	.52399 .85173	.53877 .84245	.55339 .83292	.56784 .82314	24
37 38	.50929 .86059 .50954 .86045	.52423 .85157	.53902 .84230	.55363 .83276	.56808 .82297	23
39	.50954 .86045 .50979 .86030	.52448 .85142 .52473 .85127	.53926 .84214 .53951 .84198	.55388 .83260 .55412 .83244	.56832 .82281 .56856 .82264	22 21
40	.51004 .86015	.52498 .85112	.53975 .84182	.55436 .83228	.56880 .82248	20
41	.51029 .86000	.52522 .85096	.54000 .84167	.55460 .83212	.56904 .82231	19
42 43	.51054 .85985 .51079 .85970	.52547 .85081 .52572 .85066	.54024 .84151	.55484 .83195	.56928 .82214	18
44	.51104 .85956	.52572 .85066 .52597 .85051	.54049 .84135 .54073 .84120	.55509 .83179 .5533 .83163	.56952 .82198 .56976 .82181	17 16
45	.51129 .85941	.52621 .85035	.54097 .84104	.55557 .83147	.57000 .82165	15
46	.51154 .85926	.52646 .85020	.54122 .84088	.55581 .83131	.57024 .82148	14
47 48	.51179 .85911 .51204 .85896	.52671 .85005	.54146 .84072	.55605 .83115	.57047 .82132	13
49	.51204 .85896 .51229 .85881	.52696 .84989 .52720 .84974	.54171 .84057 .54195 .84041	.55630 .83098 .55654 .83082	.57071 .82115 .57095 .82098	12 11
50	.51254 .85866	.52745 .84959	.54220 .84025	.55678 .83066	.57119 82082	10
51 52	.51279 .85851 .51304 .85836	.52770 .84943	.54244 .84009	.55702 .83050	.57143 .82065	9
53	.51304 .85836 .51329 .85821	.52794 .84928 .52819 .84913	.54269 .83994 .54293 .83978	.55726 .83034 : .55750 .83017	.57167 .82048 .57191 .82032	8
54	.51354 .85806	.52844 .84897	.54317 .83962	.55775 .83001	.57215 .82015	6
55	.51379 .85792	.52869 .84882	.54342 .83946	.55799 .82985	.57238 .81999	5
56 57	.51404 .85777	.52893 .84866	.54366 .83930	.55823 .82969	.57262 .81982	4
58	.51429 .85762 .51454 .85747	.52918 .84851 .52943 .84836	.54391 .83915 .54415 .83899	.55847 .82953 .55871 .82936	.57286 .81965 .57310 .81949	ŏ
59	.51479 .85732	.52967 .84820	.54440 .83883	.55895 .82920	.57310 .81949 .57834 .81982	4881
60	.51504 .85717	.52992 .84805	.54464 .83867	.55919 .82904	.57358 .81915	ō
,	Cosin Sine	Cosin Sine	Cosin Sine	Cosin Sine	Cosin Sine	,
	59°	58°	570	56°	550	

	8	5°	. 80	B°	3'	7°	8	3°	3	9°	
'	Sine	Cosin	′								
0	.57358	.81915	.58779	.80902	.60182	.79864	.61566	.78801	.62932	.77715	60
i	.57381	.81899	.58802	.80885	.60205	.79846	.61589	.78783	.62955	.77696	59
2	.57405	.81882	.58826	.80867	.60228	.79829	.61612	.78765	.62977	.77678	58
3 4	.57429	.81865 .81848	.58849 .58873	.80850	.60251 .60274	.79811 .79793	.61635 .61658	.78747 .78729	63000	.77660 .77641	57 56
1 3	.57477	.81832	.58896	.80816	.60298	.79776	.61681	.78711	.63045	77628	55
6	.57501	.81815	.58920	.80799	.60321	.79758	.61704	78694	.63068	.77605	54
7	.57524	.81798	.58943	.80782	.60344	.79741	.61726	.78676	.63090		53
8	.57548	.81782	.58967	.80765	.60367	.79723	.61749	.78658	.63118	.77568	52
10	.57572 .57596	.81765 .81748	.58990	.80748 .80730	.60390	.79706 .79688	.61772 .61795	.78640 .78622	.63135 .63158		51 50
11	.57619	.81781	.59087	.80718	.60487	.79671	.61818	.78604	.63180	.77518	40
12	.57643	.81714	.59061	.80696	.60460	.79658	.61841	.78586	63203	.77494	48
18	.57667	.81698	.59084	.80679	.60483	.79635	.61864	.78568	.63225	.77476	47
14	.57691	.81681	.59108	.80662	.60506	.79618	.61887	.78550	.68248	.77458	46
15	.57715	.81664 .81647	.59181	.80644	.60529	.79600 .79583	.61909 .61932	.78532 .78514	.63271 .63293	.77489 .77421	45 44
16 17	.57788 .57762	.81631	.59154	.80610	.60576	.79565	.61955	.78496	.63316	.77402	43
18	.57786	.81614	.59201	.80593	.60599	.79547	.61978	.78478	.63338	.77384	42
19	.57810	.81597	.59225	.80576	.60622	.79530	.62001	.78460	.68361	.77366	41
20	.57833	.81580	.59248	.80558	.60645	.79512	.62024	.78442	.63383	.77847	40
21	.57857	.81563	.59272	.80541	.60668		.62046	.78424	.63406	.77829	39
22	.57881 .57904	.81546 .81530	.59295	.80524	.60691	.79477	.62069	.78405 .78387	.63428 .63451	.77310 .77292	38 37
24	.57928	.81513	.59342	.80489	60738		.62115	.78369	.63478	.77273	36
25	.57952	.81496	.59365	.80472	.60761	.79424	.62138	.78351	.63496	77255	35
26	.57976	.81479	.59389	.80455	.60784	.79406	.62160	.78333	.63518	.77236 .77218	34
27	.57999	.81462	.59412	.80438	.60807	.79388	.62183	.78315	.63540	.77218	33
28 29	.58023	.81445 .81428	.59436	.80420 .80403	.60830 60853		62229	.78297 .78279	.63563	.77199 .77181	81
30	.58070	.81412	.59482	.80386	.60876		.62251	.78261	.63608	.77162	30
81	.58094	.81395	.59506	.80368	.60899	.79318	.62274	.78243	.63680	.77144	29
82	.58118	.81378	.59529	.80351	.60928		62320	.78225	.63653	.77125	28 27
83	.58141 .58165	.81361 .81344	.59552	.80334 .80316	.60945 .60968		62342	.78206 .78188	.63675	.77107	
35	.58189	.81327	.59599	.80299	60991	.79247	.62365	.78170	.63720	.77070	
36	.58212	.81310	.59622	.80282	.61015	.79229	.62388	.78152	.63742	.77051	24
87	.58236	.81293	.59646	.80264	.61038		.62411	.78134	.63765	.77083	23
38	58260 58283	.81276 .81259	.59669 .59693	.80247	.61061 .61084	.79193 .79176	62433	.78116 .78098	.63787 .63810	.77014	22
40	.58307	.81242	.59716	.80212	.61107	.79158	.62479	.78079	.63832	.76977	20
41	.58330	.81225	.59789	.80195	.61130	.79140	.62502	.78061	.63854	.76959	19
42	.58354	.81208	.59763	.80178	.61158	.79122	.62524	.78043	.63877	.76940	18
43	.58378	.81191 .81174	.59786	.80160 .80143	.61176	.79105 .79087	.62547 .62570	.78025 .78007	.63899	.76921 .76903	
45	.58425	.81157	.59832	.80125	.61222	.79069	62592	.77988	.63944	.76884	
46	.58449	.81140	.59856	.80108	.61245	.79051	.62615	.77970	.63966	.76866	14
47	.58472	81123	.59879	.80091	.61268	.79033	.62638	.77952	.63989	.76847	13
48	.58496	.81106	.59902	.80073	.61291	.79016	.62660	.77934	.64011	.76828	12
49 50	.58519 .58543	.81089 .81072	.59926 .59949	.80056 .80038	.61314 .61337	.78998 .78980	.62683 .62706	.77916	.64033	.76810 .76791	11 10
51	.58567	.81055	.59972	80021	.61360	.78962	.62728	.77879	.64078	.76772	9
52	.58590	.81038	.59995	80003	.61383	.78944	.62751	.77861	.64100	.76754	8
53	.58614	.81021	.60019	.79986	.61406	.78926	.62774	.77848	.64123	.76735	7
54	.58637	.81004 .80987	.60042	.79968 .79951	.61429	.78908	.62796	.77824 .77806	.64145	.76717	6
56	.58684	.80970	.60089	.79934	.61451 .61474	.78891	.62819 .62842	.77788	.64167	.76698 .76679	
57	.58708	.80953	.60112	.79916	.61497	.78855	.62864	.77769	.64212	.76661	3
58	.58731	.80936	.60135	.79899	.61520	.78837	.62887	.77751	.64234	.76642	2 1
59 60	.58755	.80919 .80902	.60158 .60182	.79881 .79864	.61548 .61566	.78819 .78801	.62909 .62932	.77733 .77715	.64256 .64279	.76623 .76604	0
۳ ا	Cosin	Sine	Cosin	Sine	Cosin	Sine	Cosin	Sine	Cosin		~
1										00	,
<u></u>	1 0	40	1 0	3 °	5:	ا تو	5		1 9	ا -س	1

_	40°	41°	42°	43•	44°			
1	Sine Cosin	,						
0	.64279 .76604	.65606 .75471	.66913 .74314	.68200 .73135	.69466 .71984	60		
1	.64301 .76586	.65628 .75452	.66935 .74295	.68221 .73116	.69487 .71914	59		
3	.64323 .76567	.65650 .75433	.66956 .74276 .66978 .74256	.68242 .73096 .68264 .73076	.69508 .71894	58 57		
8	.64346 .76548 .64368 .76530	.65672 .75414 .65694 .75395	.66978 .74256 .66999 .74237	.68285 .73056	.69529 .71878 .69549 .71853	56		
5	.64390 .76511	.65716 .75375	.67021 .74217	.68306 .73036	.69570 .71833	55		
6	.61412 .76492	.65738 .75356	.67048 .74198	.68327 .73016	.69591 .71818	55 54		
8	.64435 .76478 .64457 .76455	.65759 .75337 .65781 .75318	.67064 .74178 .67086 .74159	.68349 .72996 .68370 .72976	.69612 .71792 .69633 .71772	53 52		
9	.64479 .76436	65803 .75299	67107 .74139	.68391 .72957	.69654 .71752	51		
10	.64501 .76417	.65825 .75280	.67129 .74120	.68412 .72937	.69675 .71732	50		
11	.64524 .76398	.65847 .75261	.67151 .74100	.68484 .72917	.69696 .71711	49		
12 18	.64546 .76380 .64568 .76361	.65869 .75241 .65891 .75222	.67172 .74080 .67194 .74061	.68455 .72897 .68476 .72877	.69717 .71691 .69787 .71671	48 47		
14	.64590 76342	65913 .75203	.67215 .74041	.68497 .72857	.69758 .71650	46		
15	.64612 .76323	.65935 .75184	.67237 .74022	.68518 .72837	.69779 .71630	45		
16	.64635 .76304	.65956 .75165	67258 .74002	.68589 .72817	.69800 .71610	44		
17	.64657 .76286 .64679 .76267	.65978 .75146 .66000 .75126	.67280 .73983 .67301 .73963	.68561 .72797 .68582 .72777	.69821 .71590 .69842 .71569	43 42		
19	.64701 .76248	.66022 .75107	.67323 .73944	.68603 .72757	.69862 .71549	41		
20	.64723 .76229	.66044 .75088	.67344 .73924	.68624 .72737	.69883 .71529	40		
21	.64746 .76210	.66066 .75069	.67366 .73904	.68645 .72717	.69904 .71508	89		
22 23	.64768 .76192 .64790 .76173	.63038 .75030 .66109 .75030	.67387 .73885 .67409 .73865	.68666 .72697 .68688 .72677	.69925 .71488 .69946 .71468	88 87		
24	.64812 .76154	.66131 .75011	.67430 .73846	.68709 .72657	.69966 .71447	36		
25	.64834 .76185	.66153 .74992	.67452 .73826	.68730 .72637	.69987 .71427	35		
26 27	.64856 .76116 .64878 .76097	.66175 .74978 .66197 .74958	.67473 .73806 .67495 .73787	.68751 .72617 .68772 .72597	.70008 .71407 .70029 .71386	84 33		
28	.64901 .76078	.66218 .74934	.67495 .73787 .67516 .73767	68793 .72577	.70049 .71866	32		
29	.64923 .76059	.66240 .74915	.67338 .73747	.63814 .72557	.70070 .71845	31		
80	.61945 .76041	.66262 .74896	.67559 .78728	.68835 .72537	.70091 .71825	80		
81	.64967 .76022	.66284 .74876	.67580 .73708	.68857 .72517	.70112 .71305	29		
32 33	.64989 .76003 .65011 .75984	.66306 .74857 .66327 .74838	.67622 .73683 .73663	.68878 .72497 .68899 .72477	70182 .71284 .70153 .71264	28 27		
84	.65033 .75965	.66349 .74818	.67645 .73649	.68920 .72457	.70174 .71248	26		
35	.65055 .75946	.66371 .74799	.67666 .73623	.68941 .72437	.70195 .71228	85		
36 87	.65077 .75927 .65100 .75908	.66393 .74780 .66414 .74760	.67688 .73610 .67709 .73590	.68962 .72417 .68983 .72397	.70215 .71203 .70236 .71182	24 23		
88	.65122 .75889	.66436 .74741	67730 73570	.69004 .72377	.70257 .71162	22		
89	.65144 .75870	.66458 .74722	.67752 .73551	.69025 .72357	.70277 .71141	21		
40	.65166 .75851	.66480 .74703	.67773 .73531	.69046 .72337	.70298 .71121	20		
41 42	.65188 .75832 .65210 .75813	.66501 .74683 .66523 .74684	.67795 .73511 .67816 .73491	.69067 .72317 .69088 .72297	.70819 .71100 .70389 .71080	19 18		
43	.65210 .75813 .65232 .75794	.66545 .74644	.67837 .73472	69109 .72277	.70360 .71059	17		
44	.65254 .75775	.66566 .74625	.67859 .73452	.69130 .72257	.70381 .71039	16		
45	.65276 .75756	.66588 .74606	.67880 .73432	.69151 .72236	.70401 .71019	15		
46 47	.65298 .75738 .65320 .75719	.66610 .74586 .66632 .74567	.67901 .73413 .67923 .73393	.69172 .72216 .69193 .72196	.70422 .70998 .70448 .70978	14 18		
48	.65342 .75700	.66653 .74548	.67944 .73378	.69214 .72176	.70468 .70957	12		
49	65364 .75680	.66675 .74528	.67965 .73353	.69235 .72156	.70484 .70937	11		
50	.65386 .75661	.66697 .74509	.67987 .73333	.69256 .72136	.70505 .70916	10		
51 52	.65408 .75642 .65430 .75623	.66718 .74489 .66740 .74470	.68008 .73314 .68029 .73294	.69277 .72116 .69298 .72095	.70525 .70 896 .70546 .70875	9		
53	.65452 .75604	.66762 .74451	.68051 .73274	.69319 .72075	.70567 .70855	8 7 6		
54	.65474 .75585	.66783 .74431	.68072 .73254	.69340 .72055	.70587 .70834			
55 56	.65496 .75566 .65518 .75547	.66805 .74412 .66827 .74392	.68093 .73234 .68115 .73215	.69361 .72035 .69382 .72015	.70608 .70818 .70628 .70798	5		
57	.65540 .75528	.66848 .74373	.68136 .73195	.69408 .71995	.70649 .70772	8		
58	.65562 .75509	.66870 .74352	.68157 .78175	.69424 .71974	.70670 .70752	2		
59	.65584 .75490	.66891 .74834	.68179 .73155 .68200 .73135	.69445 .71954 .69466 .71934	.70690 .70781			
60	.65606 .75471 Cosin Sine	.66913 .74314 Cosin Sine	.68200 .73135 Cosin Sine	.69466 .71934 Cosin Sine	.70711 .70711 Cosin Sine	_0		
			470			•		
	49° 48°		90	46°	6° 45°			

1		0°	11	١•	i	80	1	B•	
1	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	11
0	.00000	Infinite.	.01746	57.2900	.03492	28.6368	.05241	19.0811	60
1 2	.00029	3437.75 1718.87	.01775	56.8506 55.4415	.03521	28.3994 28.1664	.05270	18.9755 18.8711	59 58
3	.00087	1145.92	.01833	54.5618	.03579	27.9372	.05328	18.7678	57
4	.00116	859.436	.01862	53,7086	.03609	27.7117	.05357	18.6656	56
5	.00145	687.549	.01891	52.8821	.03638	27.4899	.05387	18.5645	55
6	.00175	572.957 491.106	.01920	52.0807 51.3032	.03667	27.2715 27.0566	.05416	18.4645 18.8655	54 58
8	.00233	429.718	.01978	50.5485	.03725	26.8450	.05474	18.2677	52
9 10	.00262	381.971 843.774	.02007 .0203 6	49.8157 49.1089	.03754 .0378 3	26.6367 26.4316	.05508 .05588	18.1708 18.0750	51 50
11	.00320	312.521	.02066	48.4121	.03812	26.2296	.05562	17.9802	49
12	.00349	286.478	.02095	47.7395	.03842	26.0307	.05591	17.8863	48
13 14	.00378	264.441 245.552	.02124	47.0853 46.4489	.03871	25.8348 25.6418	.05620	17.7934 17.7015	47
15	.00436	229.182	.02182	45.8294	.03929	25.4517	.05678	17.6106	45
16	.00465	214.858	.02211	45.2261	.03958	25.2644	.05708	17.5205	44
17	.00495	202.219 190.984	.02240	44.6886 44.0661	.03987	25.0798 24.8978	.05787	17.4314 17.8482	43
19	.00553	180.932	.02298	43.5081	.04046	24.7185	.05795	17.2558	41
20	.00582	171.885	.02328	42.9641	.04075	24.5418	.05824	17.1698	40
21 22	.00611	163.700 156.259	.02357	42.4885 41.9158	.04104 .04138	24.3675 24.1957	.05854	17.0837 16.9990	39 38
23	.00669	149.465	.02415	41.4106	.04162	24.0268	.05912	16.9150	37
24	.00698	143.237	.02444	40.9174	.04191	23.8593	.05941	16.8819	86
25 26	.00727 .00756	137.507 132.219	.02478	40.4858 89.9655	.04220	23.6945 23.5321	.05970	16.7496 16.6681	85 84
27	.00785	127.821	.02531	39.5059	.04279	23.8718	.06029	16.5874	33
28	.00815	122.774	.02560	89.0568	.04308	23.2137	.06058	16.5075	82
29 30	.00844 .00878	118.540 114.589	.02589 .02619	38.6177 38.1885	.04337 .04366	23.0577 22.9038	.06087	16.4288 16.8499	81 80
31 32	.00902	110.892 107.426	.02648	87.7686 87.8579	.04395 .04424	22.7519 22.6020	.06145 .06175	16.2722 16.1952	29 28
33	.00960	104.171	.02706	36.9560	.04454	22.4541	.06204	16.1190	27
84	.00989	101.107	.02735	86.5627	.04483	22.3081	.06238	16.0485	27 26
35 36	.01018 .01047	98.2179 95.4895	.02764	36.1776 35.8006	.04512	22.1640 22.0217	.06262	15.9687 15.8945	25 24
37	.01076	92.9085	.02822	35.4313	.04570	21.8813	.06321	15.8211	23
38	.01105	90.4633	.02851	35.0695	.04599	21.7426	.06850	15.7488	23 22
39 40	.01185 .01164	88.1436 85.9398	.02881	84.7151 84.8678	.04628	21.6056 21.4704	.06379	15.6762 15.6048	21
41	.01198	83.8435	.02939	84.0273	.04687	21.8369	.06437	15.5340	19
42	.01222	81.8470	.02968	33.6935	.04716	21.2049	.06467	15.4688	18
43	.01251 .01280	79.9434 78.1268	.02997	33.3662 83.0452	.04745	21.0747 20 9460	.06496	15.8943 15.8254	17 16
45	.01309	76.8900	.03055	32.7303	.04808	20.8188	.06554	15.2571	15
46	.C1338	74.7292	.03084	82.4218	.04838	20.6932	.06584	15.1893	14
47 48	.01367 .01396	73.1390 71.6151	.03114	82.1181 81.8205	.04862	20.5691 20.4465	.06613	15.1222 15.0557	18 12
49	.01425	70.1533	.03172	81.5284	.04920	20.3253	.06671	14.9898	11
50	.01455	68.7501	.03201	31.2416	.04949	20.2056	.06700	14.9244	10
51 52	.01484 .01513	67.4019 66.1055	.03259	30.9599 30.6833	.04978 .05)7	20.0872 19.9702	.06730	14.8596 14.7954	9
53	.01542	64.8580	.03288	80.4116	.05037	19.8546	.06788	14.7817	7
54	.01571	68.6567	.03317	80.1446	.05066	19.7403	.06817	14.6685	6
55 56	.01600 .01629	62.4992 61.3829	.03346	29.8823 29.6245	.05095	19.6273 19.5156	.06847	14.6059	5
57	.01658	60.8058	.03405	29.3711	.05153	19.4051	.06905 14.4823		3
58	.01687	59.2659	.03434	29.1220	.05182	19.2959	0 .06934 14.4212		2
59 60	.0171 6 .017 46	58.2612 57.2900	.03463	28.8771 28.6368	.05212 .05241	19.1879 19.0811	.06963 .06993	14.8607 14.8007	0
7	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	,
	8	9•	8	8°	8	7•	8	6°	'

Table III.—Natural Tangents and Cotangents.

	4	lo i		5°	6	jo .	17	· .	7
1	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	
0	.06998	14.3007	.08749	11.4301	.10510	9.51436	.12278	8.14485	60
1 2	.07022	14.2411 14.1821	.08778	11.3919 11.3540	.10540 .10569	9.48781 9.46141	.12308	8.12481 8.10586	59 58
8	.07080	14.1235	.08837	11.3163	.10599	9.48515	.12367	8.08600	57
4	.07110	14.0655	.08866	11.2789	.10628 .10657	9.40904 9.38307	.12397 .12426	8.06674 8.04756	56 55
5	.07139 .07168	14.0079 18.9507	.08895	11.2417 11.2048	.10687	9.35724	.12456	8.02848	54
7	.07197	13.8940	.08954	11.1681	.10716	9.33155	.12485	8.00948	53
8	.07227 .0725 6	13.8378 13.7821	.08988	11.1316 11.0954	.10746	9.30599 9.28058	.12515	7.99058 7.97176	52 51
10	.07285	18.7267	.09042	11.0594	.10605	9.25530	12574	7.95802	50
11	.07814	18.6719	.09071	11.0237	.10884	9.23016	.12608	7.93438	49
12 18	.07844 .07878	18.6174 18.5684	.09101	10.9882 10.9529	.10863 .10898	9.20516 9.18028	.12633	7.91582 7.89784	48 47
14	.07402	18.5098	.09159	10.9178	.10922	9.15554	12692 12722	7.87895	46
15	.07431	18.4566	.09189	10.8829 10.8483	.10952 .10981	9.13093 9.10646	.12722	7.86064	45 44
16 17	.07490	18.4089 18.3515	.09217	10.8139	.11011	9.08211	.12781	7.82428	43
18	.07519	13.2996	.09277	10.7797	.11040	9.05789	.12810	7.80622	42
19 20	.07548 .07578	13.2480 13.1969	.09306	10.7457 10.7119	.11070 .11099	9.03379 9.00988	.12840 .12869	7.78825 7.77085	41 40
21	.07607	13.1461	.09365	10.6783	.11128	8.98598	.12899	7.75254	39
22 23	.07636 .07665	13.0958 13.0458	.09394	10.6450 10.6118	.11158 .11187	8.96227 8.93867	.12929	7.73480 7.71715	88 37
24	.07695	12.9962	.09453	10.5789	.11217	8.91520	.12988	7.69957	36
25	.07724	12.9469	.09482	10.5462	.11246	8.89185	.13017	7.68208	85
26 27	.07753 .07782	12.8981 12.8496	.09511 .09541	10.5136 10.4818	.11276	8.86862 8.84551	.13047	7.66466 7.64782	34
28	.07812	12.8014	.09570	10.4491	.11335	8.82252	.13106	7.63005	32
29 80	.07841 .07870	12.7536 12.7062	.09600	10.4172 10.8854	.11364 .11394	8.79964 8.77689	.18186 .18165	7.61287 7.59575	31 30
81	.07899	12.6591	.09658	10.3538	.11423	8.75425	.18195	7.57872	29
32 33	.07929 .07958	12.6124 12.5660	.09688	10.8224 10.2913	.11452 .11482	8.73172 8.70931	.18224	7.56176 7.54487	28 27
84	.07987	12.5199	.09746	10.2602	.11511	8.68701	.18284	7.52806	26
85 86	.08017	12.4742	.09776	10.2294 10.1988	.11541	8.66482	.18818	7.51182 7.49465	25 24
87	.08046	12.4288 12.3838	.09805	10.1683	.11570 .11600	8.62078	.18372	7.47806	23
38	.08104	12.3390	.09864	10.1381	.11629	8.59893	.18402	7.46154	22
89 40	.08134 .08163	12.2946 12.2505	.09893	10.1080	.11659 .11688	8.55555	.13432 .18461	7.44509 7.42871	21 20
41	.08192	12.2067	.09952	10.0483	.11718	8.53402	.18491	7.41240	19
42 43	.08221 .08251	12.1632 12.1201	.09981	10.0187 9.98931	.11747	8.51259 8.49128	.13521 .13550	7.89616 7.87999	18 17
44	.08280	12.1201	.10040	9.96007	.11806	8.47007	.13580	7.36389	16
45	.08309	12.0346	.10069	9.93101	.11836	8.44896 8.42795	.13609 .13639	7.84786 7.88190	15 14
46	.08339	11.9923 11.9504	.10099	9.90211 9.87338	.11865 .11895	8.40705	.13669	7.81600	13
48	.08397	11.9087	.10158	9.84482	.11924	8.38625	.13698	7.30018	12
49 50	.08427 .08456	11.8673 11.8262	.10187	9.81641 9.78817	.11954 .11983	8.36555 8.34496	.13728 .18758	7.28442 7.26873	11 10
51	.08485	11.7858	.10246	8.76009	.12018	8.32446	.13787	7.25310	9
52 53	.08514	11.7448 11.7045	.10275	9.73217	.12042	8.30406 8.28376	.13817	7.23754	8
54	.08573	11.6645	.10334	9.67680	.12101	8.26355	.13876	7.20661	6
55 56	.08602	11.6248 11.5853	.10363 .10393	9.64935 9.62205	.12131	8.24845 8.22344	.18906 .18935	7.19125 7.17594	5 4
57	.08661	11.5853 11.5461	.10393	9.59490	.12160	8.20352	.13965	7.16071	3
58	.08690	11 5072	.10452	9.56791	.12219	8.18370	.18995	7.14553 7.18042	2
59 60	.08720 .08749	11.4685 11.4801	.10481 .10510	9.54106 9.51436	.12249	8.16398 8.14435	5 .14054 7.11537		ő
7	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	
1	85°		8	4°	8	3°	82°		

Г	1	8°	11 1	9°	<u> 1</u>	.0°	11 1	1°	1
1'	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	1'
10		7.11537	.15888	6.31375	.17633	5.67128	.19438	5.14455	60
1	.14084	7.10038	.15968 .15898	6.30189	.17663	5.66165 5.65205	.19468	5.18658	59
3	.14118	7.07059	.15928	6.27829	.17728	5.64248	.19498	5.12862 5.12069	58 57
4	.14173	7.05579	.15958	6.26655	.17753	5.63295	.19559	5.11279	56
5	.14202	7.04105 7.02637	.15988	6.25486	.17783 .17813	5.62344 5.61397	.19589	5.10490	55 54
1 7	.14262	7.01174	.16047	6.23160	.17843	5.60452	.19649	5.09704 5.08921	53
18	.14291	6.99718	.16077	6.22003	.17873	5.59511	.19680	5.08139	52
9 10	.14321 .14351	6.98268 6.96828	.16107 .16187	6.20851 6.19708	.17903	5.58578 5.57688	.19710	5.07360 5.06584	51 50
11 12	.14381 .14410	6.95885 6.93952	.16167	6.18559	.17963 .17993	5.56706 5.55777	.19770 .19801	5.05809	49
18	.14440	6.92525	.16196 .16226	6.17419 6.16283	.18023	5.54851	.19881	5.05087 5.04207	48
14	.14470	6.91104	.16256	6.15151	.18053	5.53927	.19861	5.03499	46
15 16	.14499	6.89688 6.88278	.16286 .16316	6.14023 6.12899	.18083 .18118	5.53007 5.52090	.19891 .19921	5.02784 5.01971	45 44
17	.14559	6.86874	.16846	6.11779	.18143	5.51176	.19952	5.01210	43
18	.14588	6.85475	.16376	6.10664	.18173	5.50264	.19982	5.00451	42
19 20	.14618 .14648	6.84082 6.82694	.16405 .16485	6.09552 6.08444	.18203 .18233	5.49356 5.48451	.20012 .20042	4.99695 4.98940	41 40
21	.14678	6.81812	.16465	6.07340	.18263	5.47548	.20078	4.98188	89
22 23	.14707	6.79936	.16495	6.06240	.18293	5.46648	.20103	4.97488	38
24	.14737 .14767	6.78564 6.77199	.16525 .16555	6.05143 6.04051	.18323	5.45751 5.44857	.20183 .20164	4.96690 4.95945	37 36
25 26	.14796	6.75838	.16585	6.02962	.18384	5.43966	.20194	4.95201	35
26	.14826 .14856	6.74483	.16615 .16645	6.01878	.18414	5.43077 5.42192	.20224 .20254	4.94460	34 33
27 28	.14886	6.73133 6.71789	.16674	6.00797 5.99720	.18444	5.41309	.20234	4.93721 4.92984	32
29 30	.14915	6.70450	.16704	5.93646	.18504	5.40429	.20815	4.92249	81
30 31	.14945	6.69116 6.67787	.16784	5.97576 5.96510	.18534	5.89552 5.88677	.20345	4.91516	30 29
32	.15005	6.66463	.16794	5.95448	.18594	5.87805	.20406	4.90056	28
33	.15034	6.65144	.16824	5.94890	.18624	5.36936	.20436	4.89330	27
84 85	.15064 .15094	6.63831 6.62523	.16854 .16884	5.93335 5.92283	.18654 .18684	5.86070 5.85206	.20466 .20497	4.88605 4.87882	26 25
36	.15124	6.61219	.16914	5.91236	.18714	5.84345	.20527	4.87162	24
37 38	.15158	6.59921 6.58627	.16944	5.90191 5.80151	.18745	5.83487 5.32631	.20557 .20588	4.86444	23 22
39	.15183 .15218	6.57339	.17004	5.83114	.18805	5.81778	.20618	4.85013	21
40	.15243	6.56055	.17033	5.87080	.18885	5.30928	.20648	4.84300	20
41 42	.15272	6.54777 6.53503	.17063	5.86051 5.85024	.18865	5.30090 5.29235	.20679 .20709	4.83590 4.82882	19 18
43	.15302 .15332	6.52234	.17128	5.84001	.18925	5.28393	.20739	4.82175	17
44	.15362	6.50970	.17158	5.82982	.18955	5.27558	.20770	4.81471	16
45 46	.15391 .15421	6.49710 6.48456	.17183	5.81966 5.80958	.18986	5.26715 5.25880	.20800 .20830	4.80769 4.80068	15 14
47	.15451	6.47206	.17248	5.79944	.19016	5.25048	.20861	4.79370	13
48	.15481	6.45961	.17273	5.78938	.19076	5.24218	.20891	4.78678	12
49 50	.15511 .15540	6.44720 6.43484	.17303 .17333	5.77936 5.76987	.19106 .19136	5.23391 5.22566	.20921	4.77978 4.77286	11 10
51	.15570	6.42253	.17363	5.75941	.19166	5.21744 5.20925	.20982	4.76595	9
52 53	.15600 .15630	6.41026 6.39804	.17398 .17428	5.74949 5.73960	.19197	5.20107	.21013 .21043	4.75906 4.75219	8
54	.15660	6.38587	.17453	5.72974	.19257	5.19293	.21078	4.74534	6
55 56	.15689	6.37374 6.36165	.17488 .17518	5.71992 5.71013	.19287	5.18480 5.17671	.21104	4.73851 4.73170	5 4
57	.15719 .15749	6.84961	.17548	5.70037	.19317	5.16863	.21164	4.72490	8
58	.15779	6.88761	.17578	5.69064	.19378	5.16058	.21195	4.71813	2
59 60	.15809 .15838	6.32566 6.81375	.17608 .17688	5.68094 5.67128	.19408 .19438	5.15256 5.14455	.21225 .21256	4.71137 4.70468	0
 	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	,
	81°		80°		79°		7	l	

	1	2•	1	3•	1	4 °	1	5°	
'	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	1
0	.21256	4.70468	.23087	4.83148	.24938	4.01078	.26795	8.78205	60
1 1	.21286 .21316	4.69791	.23117 .23148	4.89578 4.89001	.24964	4.00582	.26826 .26857	3.72771 8.72338	59 58
2 8	.21347	4.68452	.23179	4.81480	.25026	8.99592	.26888	3.71907	57
4	.21377	4.67786	.23209	4.80860	.25056	8.99099	.26920	8.71476	56
5	.21408	4.67121	.23240	4.30291	.25087	8.98607	.26951 .26982	8.71046 8.70616	55 54
6	.21438 .21469	4.66458 4.65797	.23271	4.29159	.25118 .25149	8.98117 8.97627	.27013	8.70188	58
8	.21499	4.65138	.23332	4.28595	.25180	8.97189	.27044	8.69761	52
10	.21529 .21560	4.64480 4.63825	.23363 .23398	4.28032 4.27471	.25211	8.96651 8.96165	.27076 .27107	8.69335 8.68909	51 50
11	.21590	4.63171	.23424	4.26911	.25278	8.95680	.27138	8.68485	49
12	.21621	4.62518	.23455	4.26352	.25304	8.95196	.27169	8.68061	48
18 14	.21651 .21682	4.61868 4.61219	.23485	4.25795	.25335 .25366	8.94718 8.94282	.27201 .27232	3.67638 8.67217	47 46
15	.21712	4.60572	.23547	4.24685	.25897	8.93751	.27263	8.66796	45
16	.21743	4.59927	.23578	4.24132	.25428	8.93271	.27294 .27326	8.66376	44
17 18	.21778 .21804	4.59288 4.58641	.23608 .23639	4.23580 4.23630	.25459 .25490	8.92798 8.92316	.27357	8.65957 8.65538	43 42
19	.21834	4.58001	.23670	4.22481	.25521	8.91839	.27388	8.65121	41
20	.21864	4.57868	.23700	4.21933	.25552	8.91864	.27419	8.64705	40
21 22	.21895 .21925	4.56726 4.56091	.23731 .23762	4.21387 4.20842	.25583 .25614	8.90890 8.90417	.27451 .27482	8.64289 8.63874	39 38
23	.21956	4.55458	.23793	4.20298	.25645	8.89945	.27518	8.63461	37
24	.21986	4.54826	.23828	4.19756	.25676	8.89474	.27545	8.63048	86
25 26	.22017 .22047	4.54196 4.53568	.23854 .23885	4.19215 4.18675	.25707 .25738	3.89004 3.88586	.27576 .27607	3.62636 3.62224	85 84
27	.22078	4.52941	.23916	4.18137	.25769	8.88068	27638	8.61814	83
28	.22108	4.52316	.23946	4.17600	.25800	8.87601	.27670	8.61405	82
29 30	.22139 .22169	4.51698 4.51071	.23977 .24008	4.17064 4.16530	.25831 .25862	8.87186 8.86671	.27701 .27782	8.60996 8 60588	81 80
31 32	.22200 .22231	4.50451 4.49889	.24039 .24069	4.15997 4.15465	.25998 .25924	8.86208 8.85745	.27764 .27795	3.60181	29 28
33	.22261	4.49088	.24100	4.14984	.25955	8.85284	.27826	8.59775 8.59870	27
84	.22292	4.48600	.24181	4.14405	.25986	3.84824	.27858	8.58966	26
35	.22322	4.47986	.24162 .24193	4.13877 4.13350	.26017 .26048	8.84364 8.83906	.27889 .27921	8.58562 8.58160	25 24
36 87	.22383	4.47374	.24223	4.12825	26079	3.83442	27952	8.57758	23
88	.22414	4.46155	.24254	4.12301	.26110	3.82992	.27983	8.57857	22
89 40	.22444 .22475	4.45548 4.44942	.24285 .24316	4.11778 4.11256	.26141 .26172	3.82537 8.82063	.28015 .28046	3.56957 8.56557	21 20
41	.22505	4.44888	.94847	4.10736	.26203	8.81630	.28077	8.56159	19
42 43	.22536 .22567	4.48785 4.43184	.24877 .24408	4.10216 4.09699	.26235 .26266	3.81177 3.80726	.28109 .28140	8.55761 8.55864	18
44	.22597	4.42584	.24439	4.09182	.26297	8.80276	.28172	8.54968	16
45	.22628	4.41986	.24470	4.08666	.26328	8.79827	.28203	8.54578	15
46	.22658 .22689	4.41840 4.40745	.24501 .24532	4.08152	.26859 .26890	8.79878 8.78931	.28234 .28266	3.54179 3.53785	14 18
48	.22719	4.40152	.24562	4.07127	.26421	8.78485	.28297	8.53393	12
49	.22750	4.39560	.24593	4.06616	.26459	8.78040	.28329	8.53001	11
50 51	.22781	4.88969	.24624	4.06107	.26488	8.77595 8.77152	.28360	8.52609 8.52219	10 9
52	.22842	4.87798	.24686	4.05092	.26546	8.76709	.28423	8.51829	181
53	.22872	4.87207	.24717	4.04586	.26577	8.76268	.28454	8.51441	6
54 55	.22908 .22934	4.86628 4.86040	.24747	4.04081 4.08578	.26608 .26639	8.75828 8.75888	.28486 .28517	8.51058 8.50666	5
56	.22964	4.85459	.24809	4.03076	.26670	8.74950	.28549	8.50279	4
57	.22995	4.84879	.24840	4.02574	.26701	8.74512	.28580	8.49894	18
58 59	.23026 .23056	4.84800 4.83728	.24871 .24902	4.02074 4.01576	.26733 .26764	8.74075 8.73640	.28612 .28648	8.49509 8.49125	2
60	.23087	4.83148	.24933	4.01078	.26795	3.73205	.28675	8.48741	ō
1	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	,
i	7	7°	li 7	6°	7	5°	7	4°	ı

Γ.	1. 1	16°	111	7°	1	8°	1	9°	١.
1	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	'
10		8.48741	.30578	8.27085	.32492	8,07768	.34433	2.90421	60
1	.28706	8.48359	.80605	8.26745	.32524	8.07464	.84465	2.90147	59
8	.28738	8.47977	.80637	8.26406	.32556 .32588	3.07160 3.06857	.84498	2.89878	58
4		8.47596 8.47216	.80669 .80700	8.26067 8.25729	.32588	8.06554	.34530	2.89600 2.89827	57 56
5		8.46837	30732	8.25392	.32653	8.06252	.84596	2.89055	55
6		8.46458	.30764	8.25055	.32685	8.05950	.84628	2.88783	54
7		8.46080	.30796	8.24719	.32717	3.05649	.84661	2.88511	58
8		8.45703 8.45327	.30828	8.24383 8.24049	.32749 .32782	8.05349 8.05049	.34693	2.88240 2.87970	52 51
10		8.44951	.80891	8.28714	.32814	8.04749	.84758	2 87700	50
11 12	.29021 .29053	8.44576 8.44202	.30923	3.23381 3.23048	.32846	8.04450	.84791	2.87480	49
18		8.43829	.30987	8.22715	.82911	3.04152 3.03854	.84824	2.87161 2.86892	48 47
		8.43456	81019	8.22384	.82943	8.03556	.34889	2.86624	46
14 15	.29147	3.43084	.81051	8.22058	.82975	8.03260	.84922	2.86856	45
16	.29179	8.42718	.81088	8.21722	.33007	8.02963	.84954	2.86089	44
17 18	.29210	8.42348 3.41978	.81115 .81147	8.21392 8.21063	.33040	3.02667 3.02372	.84987 .85020	2.85822 2.85555	43 42
19	.29274	8.41604	.81178	8.20734	.83104	3.02077	.85052	2.85289	41
20	.29305	8.41296	.81210	8.20406	.83136	8.01783	.85085	2.85023	40
21	.29337	8.40869	.81242	8.20079	.83169	3.01489	.35118	2.84758	39
22 23	.29368	8.40502 8.40186	.81274 .81306	8.19752 8.19426	.83201	3.01196 3.00903	.85150 .85183	2.84494 2.84229	38 37
24	.29432	8.39771	.81838	8.19100	.83266	8.00611	.85216	2.83965	86
28	.29463	3.39406	.81370	8.18775	.83298	8.00319	.85248	2.83702	85
26 27	.29495	8.89042	.31402	8.18451	.33330	8.00028	.85281	2.83489	84
27	.29526	8.38679	.81434	8.18127	.83368	2.99738 2.99447	.85814	2.83176 2.82914	83 82
28 29	.29558	3.38317 3.37955	.81466 .81498	8.17804 8.17481	.83395 .83427	2.99158	.85346 .85879	2.82658	31
30	.29621	8.87594	.81530	8.17159	.83460	2.98868	.85412	2.82391	80
31	.29653 .29685	8.37234 8.36875	.81562	8.16838	.83492 .83524	2.98580 2.98292	.85445 .85477	2.82130 2.81870	29
32 33	.29716	8.36516	.31594 .31626	8.16517 8.16197	.33557	2.98004	.85510	2.81610	28 27
84	29748	8.86158 8.85800	.81658	8.15877	.83589	2.97717	.85548	2.81850	26
35 36 37	.29780		.81690	8.15558	.83621	2.97430	.85576	2.81091	25
90	.29811	8.85448 8.85087	.81722 .81754	8.15240 8.14923	.83654	2.97144 2.96858	.85608 .85641	2.80888 2.80574	24 23
38	.29875	8.84782	.81786	8.14605	.33718	2.96573	.85674	2.80316	22
39	.29906	8.34377	.31818	8.14288	.33751	2.96288	.85707	2.80059	21
40	.29938	8.34023	.81850	8.13972	.88788	2.96004	.85740	2.79802	20
41 42	.29970 .30001	8.88670 8.88817	.81882	8.18656	.83816 .83848	2.95721 2.95437	.85772 .85805	2.79545 2.79289	19 18
48	.80033	8.82965	.31914 .31946	8.18841 8.13027	.83881	2.95155	.85838	2.79033	17
44	.80065	8.82614	.31978	8.12718	.83913	2.94872	.85871	2.78778	16
45	.80097	8.82264	.32010	8.12400	.88945	2.94591	.35904	2.78523	15
46 47	.30128 .30160	3.81914 3.81565	.82042 .82074	8.12087 8.11775	.88978 .84010	2.94809 2.94028	.85937 .85969	2.78269 2.78014	14 13
48	.80192		.82106	8.11464	.84048	2.94028	.36002	2.77761	12
49	.80224	8.80868	.82139	8.11158	34075	2.93468	.86035	2.77507	11
50	.80255	8.30521	.82171	8.10843	.34108	2.93189	.86068	2.77254	10
51 52	.80287 .80819	8.80174 8.29829	.32235	8.10532 8.10223	.84140 .84178	2.92910 2.92632	.36101 .36134	2.77002 2.76750	9
58	.30351	8.29483	.82267	8.09914	.84205	2.92354	.86167	2.76498	8
54	.80382	8.29189	.32299	8.09606	.84288	2.92076	.86199	2.76247	6
55	.80414	8.28795	.82331	8.09298	.34270	2.91799	.86232	2.75996	5
56 57	.80446 .80478	8.28452 8.28109	.32368 .32396	8.08991 8.08685	.84308 .84885	2.91523 2.91246	.86298	2.75746 2.75496	8
58	.80509	8.27767	.32428	8.08879	.84868	2.90971	.86331	2.75246	2
59	.80541	8.27426	.32460	8.08078	.84400	2.90696	.36364	2.74997	1
<u>60</u>	.80578	3.27085	.82492	8.07768	.84488	2.90421 Teng	.86897 Cotang	2.74748 Tang	0
,	Cotang	Tang	Cotang	Tang	Cotang	Tang			
	7	3°	i 7	2º	1 7	1°	1 7	0°	

,	2	0°	2	1°	2	2°	2	3°	
	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	
0	.36397	2.74748	.88386	2.60509	.40403	2.47509	.42447	2.85585	60
1 2	.36430 .36463	2.74499 2.74251	.38490	2.60283 2.60057	.40436 .40470	2.47302 2.47095	.42516	2.35395 2.35205	59 58
8	.86496	2.74004	.38487	2.59881	40504	2.46888	.42551	2.85015	57
4 5	.36529 .36562	2.73756 2.73509	.88520 .88553	2.59606 2.59381	.40538	2.46682 2.46476	.42585	2.34825 2.34636	56 55
6	.86595	2.73268	.88587	2.59156	40606	2.46270	42654	2.84447	54
7	.36628	2.73017	.38620	2.58932	.40640	2.46065	.42688	2.34258	58
8; 9	.86661 .86694	2.72771 2.72526	.38654 .38687	2.58708 2.58484	.40674	2.45860 2.45655	.42722 .42757	2.34069 2.33881	52 51
10	.86727	2.72281	.88721	2.58261	.40741	2.45451	.42791	2.33693	50
11	.86760	2.72086	.88754	2.58088	.40775	2.45946	.42826	2.83505	49
12 18	.36793 .36826	2.71792 2.71548	.88787 .88821	2.57815 2.57598	.40809 .40843	2.45048 2.44839	.42860 .42894	2.83317 2.83180	48 47
14	.86859	2.71305	.88854	2.57371	40877	2.44686	.42929	2.82943	46
15 16	.36892	2.71062 2.70819	.38888	.88921 2.56928		2.44488 2.44290	.42963 .42998	2.32756 2.32570	45
17	.86925 .86958	2.70819 2.70577		.88955 2.56707		2.44027	.43032	2.32383	43
18	.36991	2.70835	.88988	.88988 2.56487		2.43825	.43067	2.32197	42
19 20	.87024 .87057	2.70094 2.69858	.89022	.89022 2.56266 .89055 2.56046		2.43628 2.43422	.43101 .48136	2.32012 2.31826	41 40
21	.87090	2.69612	.89089	2.55927	.41081	2.43220	.48170	2.81641	39
22	.87128	2.69371	.89122	2.55608	.41149	2.43019	.43205	2.31456	38
23 24	.87157	2.69131 2.68892	.89156	2.55389	.41188 .41217	2.42819 2.42618	.43233	2.81271 2.81086	37 36
25	.87190 .87228	2.68892 2.68658	.39190 .89228	2.55170 2.54952	.41251	2.42418	.43308	2.30902	85
26	.37256	2.68414	.89257	2.54784	.41285	2.42218	.43343	2.30718	84
27 28	.37289 .87322	2.68175 2 67937	.89290 .89324	2.54516 2.54299	.41819 .41858	2.42019 2.41819	.43378 .43412	2.30534	83 82
29	.37355	2.67700	.39357	2.54082	.41387	2.41620	.43447	2.80167	81
80	.87388	2.67462	.89891	2.53865	.41421	2.41421	.43481	2.29984	30
81 82	.87422 .87455	2.67225 2.66969	.89425	2.53648 2.53432	.41455 .41490	2.41228 2.41025	.48516 .48550	2.29801 2.29619	29 28
88	.87488	2.66752	.89492	2.53217	41524	2.40827	.43585	2.29487	27
84 85	.87521	2.66516	.89526	2.53001	.41558	2.40629 2.40432	.43620 .43654	2.29254 2.29073	26 25
36	.37554 .37588	2.66281 2.66046	.89559 .89593	2.52786 2.52571	.41598 .41626	2.40235	.43689	2.28891	24
87	.87621	2.65811	.89626	2.52357	.41660	2.40038	.43724	2.28710	23 22
38 39	.37654 .37687	2.65576 2.65342	.89660 .89694	2.52142 2.519.9	.41694 .41728	2.89841 2.89645	.43758	2.28528 2.28348	21
40	.87720	2.65109	.89727	2.51715	.41763	2.89449	43828	2.28167	20
41	.87754	2.64875	.89761	2.51502	.41797	2.89253	.43862	2.27987	19
42 43	.87787 .87820	2.64642 2.64410	.89795 .39829	2.51289 2.51076	.41831 .41865	2.89058 2.88863	.43897 .43932	2.27806 2.27626	18 17
44	. 37853	2.64177	.39862	2.50864	41899	2.88668	.43966	2.27447	16
45 46	.87887	2.63945 2.63714	.89896 .89930	2.50652 2.50440	.41933 .41968	2.38473 2.38279	.44001 .44036	2.27267 2.27088	15 14
47	.37920 .37958	2.63483	.89968	2.50229	.42002	2.38084	.44071	2.26909	18
48	. 37986	2.63252	.39997	2.50018	.42036	2.37891	.44105	2.26730 2.26552	12 11
49 50	.38020 .38053	2.63021 2.62791	.40031 .40065	2.49807 2.49597	.42070 .42105	2.87697 2.87504	.44140 .44175	2.26552 2.26374	10
51	.38086	2.62561	.40098	2.49886	.42139	2.87811	.44210	2.26196	9
52	.38120	2.62332	.40132	2.49177	.42173	2.37118	.44244	2.26018	8
53 54	.38153 .38186	2.62103 2.61874	40166	2.48967 2.48758	.42207	2.36925 2.36733	.44279	2.25840 2.25663	7
55	.38220	2.61646	40234 2.48549 .42276 2.5		2.36541	.44849	2.25486	5	
56	. 38253	2.61418	.40267 2 48340		.42310 .42345	2.36349 2.36158	.44384 .44418	2.25309 2.25132	8
57 58	.88286 .88320	2.61190 2.60963	.40301 2.48132 .40335 2.47924		.42345	2.35967	.44453	2.24956	2 1
59	. 38353	2.60736	.40369	2.47716	.42418	2.85776	.44488	2 24780	10
60	.38386 Cotang	2.60509 Tang	.40408 Cotang	2.47509 Tang	.42447 Cotang	2.85585 Tang	.44523 Cotang	2.24604 Tang	-
,		<u> </u>	II ———						1
	6	9°	11 6	80	1 6	7•	11 6	6°	

	2	40	2	5°	2	6°	2	7°	
'	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	!
0	.44523	2.24604	.46631	2.14451	.48778	2.05030	.50953	1.96261	60
1 2	.44558 .44598	2.24428 2.24252	.46666	2.14288 2.14125	.48809 .48845	2.04879 2.04728	.50989 .51026	1.96120	59 58
8	.44627	2.24077	.46737	2.13963	.48881	2.04577	.51026	1.95838	57
4	.44662	2.23902	.46772	2.13801	.48917	2.04426	.51099	1.95698	56
5	.44697	2.23727	.46808	2.13639	.48953	2.04276	.51136	1.95557	55
6	.44732 .44767	2.23553 2.23378	.46848	2.13477 2.13316	.48989 .49026	2.04125 2.03975	.51173	1.95417 1.95277	54 58
8	.44802	2.23204	.46914	2.13154	.49062	2.03825	.51246	1.95187	52
9	.44837	2.23030	.46950	2.12993	.49098	≠.08675	.51288	1.94997	51
10	.44872	2.22857	.46985	2.12832	.49134	2.03526	.51319	1.94858	50
11 12	.44907 .44942	2.22683 2.22510	.47021	2.12671 2.12511	.49170 .49206	2.03376 2.03227	.51356	1.94718	49
13	.44977	2.22337	.47056 .47092	2.12311	.49200	2.03227	.51393 .51430	1.94579 1.94440	48
14	.45012	2.22164	.47128	2.12190	.49278	2.02929	.51467	1.94301	46
15	.45047	2.21992	.47168	2.12030	.49315	2.02780	.51503	1.94162	45
16	.45082 .45117	2.21819 2.21647	.47199 .47234	2.11871 2.11711	.49351 .49387	2.02631 2.02483	.51540	1.94023	44 48
18	45152	2.21475	47270	2.11552	49423	2.02335	.51614	1.93746	42
19	.45187	2.21304	.47805	2.11392	.49459	2.02187	.51651	1.93608	41
20	.45222	2.21132	.47841	2.11233	.49495	2.02039	.51688	1.93470	40
21 22	.45257 .45292	2.20790 2.20790	.47377 .47412	2.11075 2.10916	.49532 .49568	2.01891 2.01743	.51724	1.93333	39 38
23	.45327	2.20619	47448	2.10758	.49505	2.01743	.51798	1.93195	37
24	.45362	2.20449	.47488	2.10600	.49640	2.01449	.51835	1.92920	36
25	.45397	2.20278	.47519	2.10442	.49677	2.01302	.51872	1.92782	35
26	.45432 .45467	2.20108 2.19938	.47555 .47590	2.10284 2.10126	.49718	2.01155 2.01008	.51909 .51946	1.92645	34 33
27	.45502	2.19769	.47626	2.09969	.49786	2.00862	.51983	1.92371	32
29	.45538	2.19599	.47662	2.09811	.49822	2.00715	.52020	1.92235	31
80	.45578	2.19430	.47698	2.09654	.49858	2.00569	.52057	1.92098	30
31	.45608	2.19261	.47738	2.09498	.49894	2.00423	.52094	1.91962	29
32 33	.45648 .45678	2.19092 2.18923	.47769 .47805	2.09341 2.09184	.49931 .49967	2.00277 2.00131	.52131	1.91826 1.91690	28 27
84	.45718	2.18755	.47840	2.09028	.50004	1.99986	.52205	1.91554	26
85	.45748	2.18587	.47876	2.08872	.50040	1.99841	.52242	1.91418	25 24
36 37	.45784 .45819	2.18419 2.18251	.47912	2.08716 2.08560	.50076	1.99695 1.99550	.52279 .52316	1.91282 1.91147	23
38	.45854	2.18084	.47984	2.08405	.50149	1.99406	.52353	1.91012	23 22
39	.45889	2.17916	.48019	2.08250	.50185	1.99261	.52390	1.90876	21 20
40	.45924	2.17749	.48055	2.08094	.50222	1.99116	.52427	1.90741	
41	.45960	2.17582	.48091	2.07939 2.07785	.50258	1.98972 1.98828	.52464 .52501	1.90607	19 18
43	.45995 .46030	2.17416 2.17249	.48127 .48168	2.07630	.50331	1.98684	.52538	1.90472	17
44	.46065	2.17083	.48198	2.07476	.50368	1.98540	.52575	1.90203	16
45	.46101	2.16917	.48234	2.07321 2.07167	.50404	1.98396 1.98253	.52618	1.89935	15
46 47	.4613 6 .4617 1	2.16751 2.16585	.48306	2.07167	.50441	1.98253	.52687	1.89935	13
48	.46206	2.16420	.48342	2.06860	.50514	1.97966	.52724	1.89667	12
49	.46242	2.16255	.48378	2.06706	.50550	1.97823	.52761	1.89533 1.89400	11 10
50	.46277	2.16090	.48414	2.06553	.50587	1.97681			1 1
51 52	.46312 .46348	2.15925 2.15760	.48450 .48486	2.06400 2.06247	.50628	1.97538 1.97395	.52836	1.89266 1.89133	9
58	.46383	2.15596	.48521	2.06094	.50696	1.97258	.52910	1.89000	8
54	.46418	2.15432	.48557	2.05942	.50733	1.97111	.52947	1.88867	6
55 56	.46454 .46489	2.15268 2.15104	.48593	2.05790 2.05637	.50769	1.96969	.52985	1.88734	5
57	.46525	2.14940	.48665	2.05485	.50843	1.96685	.53059	1.88469	8
58	.46560	2.14777	.48701	2.05333	.50879	1.96544	.53096	1.88837	2
59 60	.46595 .46631	2.14614 2.14451	.48737 .48773	2.05182 2.05030	.50916	1.96402 1.96261	.53134	1.88205	å
=	Cotang	Tang	Cotang		Cotang	Tang	Cotang	Tang	-
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1	6	5°	11 6	4°	ii 6	30	. 6	2°	i

1 5.8396 1.87941 5.5491 1.90405 5.7773 1.73908 6.0026 2.53246 1.87690 5.5549 1.80188 5.7813 1.73973 6.0165 3.53283 1.87677 5.5545 1.80188 5.7813 1.73267 6.00265 6.53830 1.87546 5.5583 1.79011 5.7890 1.72741 6.0245 6.53830 1.87546 5.5583 1.7911 5.7890 1.72741 6.0245 6.53836 1.87415 5.56921 1.79788 5.7929 1.72625 6.0284 7.58432 1.87152 5.5697 1.79642 5.5907 1.72533 6.0364 7.58432 1.87152 5.5697 1.79642 5.5907 1.72533 6.0364 7.58432 1.87152 5.5697 1.79642 5.5007 1.72533 6.0364 7.58432 1.80700 5.5812 1.79174 5.8124 1.72047 6.0483 1.58362 1.86700 5.5880 1.79061 5.8065 1.72163 6.0443 1.58362 1.86700 5.5883 1.78029 5.8901 1.7102 6.0602 12.53936 1.80899 5.5986 1.78067 5.8942 1.80239 5.5986 1.78067 5.8942 1.79174 5.8124 1.72047 6.0662 13.53677 1.86369 5.5986 1.78067 5.8940 1.78067 5.5986 1.78067 5.8940 1.78067 5.5986 1.78067 5.8940 1.78067 5.5986 1.78067 5.5894 1.80239 5.5984 1.78089 5.8991 1.71170 6.0602 11.53894 1.80239 5.5984 1.78063 5.8813 1.71473 6.0081 15.53782 1.85850 5.50079 1.78319 5.8989 1.711898 6.0041 1.58860 5.5890 1.78063 5.8813 1.71173 6.0081 19.53892 1.85462 5.6116 1.78077 5.8474 1.71015 6.0081 19.53892 1.85462 5.6116 1.78077 5.8474 1.71015 6.0081 19.53892 1.85462 5.6116 1.78077 5.8474 1.71015 6.0081 19.53892 1.85462 5.6156 1.78077 5.8474 1.71015 6.0081 19.53892 1.85462 5.6156 1.78077 5.8474 1.70091 6.0081 1.7505 5.8513 1.70901 6.0081 1.58067 1.84848 5.56370 1.7713 5.8501 1.7060 6.0081 1.7060 5.5813 1.7060 6.0081 1.7060 5.5813 1.7060 6.0081 1.7060 5.5813 1.7060 6.0081 1.7060 5.5813 1.7060 6.0081 1.7060 5.5813 1.7060 6.0081 1.7060 5.5813 1.7060 6.0081 1.7060 5.5813 1.7060 6.0081 5.	, 1	2	8°	; 2	9°	3	0°	. 3	1°	1.
1. 58206	1	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	'
2 5.83246 1.87809 5.5507 1.80158 57813 1.72957 6.0205 4 5.83388 1.876745 5.5583 1.79911 57800 1.72741 60245 5 5.33368 1.87145 5.5583 1.79685 5.7968 1.72509 60284 6 5.5395 1.87122 5.5667 1.79665 5.7968 1.72509 60284 7 5.5432 1.87621 5.5774 1.79652 58007 1.72233 60483 9 5.3547 1.86690 5.5812 1.79174 56124 1.72047 60483 10 5.3542 1.86630 5.5880 1.79051 58162 1.71982 60422 12 5.3630 1.86499 55826 1.78675 58240 1.71702 60602 12 5.3630 1.86299 55926 1.78685 58279 1.71702 60602 12 5.3630 1.85879 56041 1.78685 58289 1.711702 <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>1.66428</td> <td>60</td>									1.66428	60
8 5.93283 1.876476 5.55485 1.99011 5.7800 1.72741 60245 5 5.53386 1.87415 5.5621 1.79788 5.7929 1.72642 60245 6 5.5356 1.87283 5.5659 1.79662 5.7968 1.72509 60324 7 5.5432 1.87021 5.5736 1.79419 58946 1.72273 60468 9 5.3507 1.86891 5.5774 1.79419 58946 1.72273 60448 10 5.3645 1.86690 55891 1.79174 58124 1.72047 60488 11 5.3582 1.86690 55880 1.78921 58291 1.71170 60662 12 5.3620 1.86499 55964 1.78867 58291 1.711702 60662 15 5.3732 1.86199 55064 1.78865 58279 1.71588 60642 15 5.3894 1.88720 56017 1.78199 58343 1.71473	1				1.80281				1.66318	59
4 8.5320 1. 87546 5.5583 1. 7968 5.7929 1. 72625 60284 5 5.3358 1. 87152 5.56697 1. 79685 5.7928 1. 72509 60284 7 5.3432 1. 87152 5.5697 1. 79642 58007 1. 72238 60384 8 5.3470 1. 87021 5.5736 1. 79149 58045 1. 72278 60483 9 5.3507 1. 86891 5.5774 1. 79051 58080 1. 72047 60483 10 5.3542 1. 86690 5.5881 1. 79051 58162 1. 71992 60522 12 5.3630 1. 86499 55926 1. 78085 58240 1. 71702 60602 14 5.3694 1. 8629 55926 1. 78085 58279 1. 71588 60422 15 5.5732 1. 86109 58930 1. 71702 60602 16 5.5769 1. 8573 1. 78188 58279 1. 71588 60422			1.87677						1.66099	58 57
6 53936 1.87328 55659 1.79625 57968 1.72598 60364 7 53432 1.87132 55697 1.72432 58007 1.72238 60364 8 53470 1.86901 55774 1.79296 58086 1.72278 60448 10 53545 1.86700 55812 1.79174 58124 1.72174 60483 11 58582 1.86690 55881 1.79611 58163 1.71982 60622 12 58620 1.86399 55923 1.7807 58240 1.71702 60662 14 53697 1.86109 56003 1.78685 58879 1.71588 60642 15 53782 1.86109 56003 1.78685 58879 1.71588 60721 17 53894 1.85200 560179 1.78198 58436 1.71244 60761 18 53842 1.86591 56166 1.78077 58474 1.71015 60641 <td>4</td> <td>.53320</td> <td></td> <td>.55583</td> <td></td> <td>.57890</td> <td></td> <td>.60245</td> <td>1.65990</td> <td>56</td>	4	.53320		.55583		.57890		.60245	1.65990	56
7 5.8432 1. 87152 5.5697 1. 79542 58007 1. 72236 6.0468 8 5.8570 1. 86891 .56774 1. 79296 .58065 1. 72273 .60448 9 .53507 1. 86891 .56774 1. 79296 .58086 1. 72273 .60448 11 .58582 1. 86690 .55886 1. 79974 .58124 1. 72247 .60483 12 .58620 1. 86899 .55886 1. 78977 .68240 1. 71702 .60602 13 .55867 1. 86899 .55964 1. 78863 .58818 1. 71702 .60602 15 .53732 1. 86109 .6003 1. 78663 .58818 1. 71473 .60681 16 .53769 1. 85879 .56041 1. 78886 .58818 1. 71473 .60681 16 .53769 1. 85890 .56177 1. 78186 .58435 1. 71147 .60761 18 .53847 1. 85720 .56144 1. 777055									1.65881	55
8 53470 1.87021 55736 1.79419 58046 1.72278 60408 10 53545 1.86760 55812 1.79174 58124 1.72047 60483 11 53582 1.86300 55880 1.79051 58162 1.7102 60423 12 53820 1.86499 55888 1.79051 58162 1.7102 60602 13 53657 1.86389 55926 1.78807 58240 1.71702 60602 14 53694 1.86239 55964 1.78635 58318 1.7173 60661 15 53732 1.86109 56003 1.78655 58318 1.71473 60661 15 53732 1.86109 56003 1.78655 58318 1.71473 60681 16 53769 1.85850 55079 1.7819 58396 1.71234 60721 17 53807 1.85850 55079 1.7819 58396 1.71244 60761 18 53844 1.85720 56117 1.78196 58435 1.71129 60601 19 538920 1.85462 56154 1.78077 58474 1.71015 60841 1.7865 58513 1.70901 60881 20 538920 1.85462 56154 1.77805 58513 1.70901 6081 22 53908 1.85904 56270 1.77713 58851 1.70501 6081 22 53908 1.85904 56270 1.77713 58851 1.70501 6081 22 53908 1.85904 56270 1.77713 58851 1.70673 60960 24 54070 1.84946 56347 1.77471 58570 1.7046 611040 22 54145 1.84689 56424 1.77720 56748 1.70219 61120 27 54188 1.44561 56462 1.77110 55787 1.70129 61120 27 54188 1.44561 56462 1.77110 55787 1.70129 61120 27 54188 1.44561 56462 1.77110 55748 1.70219 61120 27 54188 1.44561 56462 1.77690 58865 1.69879 61240 23 54251 1.83922 56654 1.78510 58938 1.69541 61360 61400 61400 61500 61400 61500	6								1.65772 1.65663	54 53
10									1.65554	52
11 58582 1.86490 .55880 1.79051 .58901 1.71982 .60622 12 .53620 1.86499 .55926 1.78920 .58801 1.71187 .60662 14 .53804 1.86289 .55926 1.78635 .58279 1.71588 .60622 15 .53732 1.86109 .66031 1.78635 .58318 1.71473 .60681 16 .53769 1.85879 .56041 1.78441 .58857 1.7138 .60631 17 .58907 1.85850 .56174 1.78411 .58857 1.7139 .60611 18 .58444 .85720 .56117 1.78198 .58435 .7129 .60641 20 .53890 1.85462 .56194 1.77765 .58513 1.7015 .60641 21 .53967 1.85333 .56232 1.77731 .58501 1.70673 .6060 22 .53965 1.85075 .56391 1.77731 .58701 <td< td=""><td>9</td><td>.53507</td><td>1.86891</td><td>.55774</td><td>1.79296</td><td>.58085</td><td>1.72163</td><td>.60448</td><td>1.65445</td><td>51</td></td<>	9	.53507	1.86891	.55774	1.79296	.58085	1.72163	.60448	1.65445	51
12 53820 1 86499 55898 1 78929 58940 1 71702 60602 13 53657 1 86369 55926 1 78807 58240 1 71702 60602 14 53894 1 86239 55964 1 78865 58279 1 71588 60642 15 53732 1 86109 66003 1 78863 58279 1 71588 60721 16 53769 1 85979 56041 1 78441 58357 1 71358 60721 17 53807 1 85850 56079 1 78819 58836 1 71244 60761 18 53844 1 85729 56117 1 78199 58896 1 71244 60761 19 53882 1 85591 56156 1 78077 58474 1 71015 60841 20 538920 1 1 1 1 1 1 1 1 1 21 53897 1 85383 56238 1 77857 58518 1 70901 60881 21 53897 1 85383 56238 1 77755 58518 1 70901 60881 22 53995 1 85383 56238 1 77759 58631 1 70573 60960 23 54032 1 84046 56347 1 77751 58670 1 70473 60960 24 54070 1 84486 56452 1 77713 58709 1 70382 61060 25 54145 1 84889 56424 1 77230 58767 1 70382 61060 26 54145 1 84889 56424 1 77230 58767 1 70106 61160 28 54220 1 84436 56462 1 77710 58767 1 70106 61160 29 54288 1 84361 56462 1 77710 58767 1 70106 61160 29 54288 1 84361 56462 1 77710 58787 1 70106 61160 29 54288 1 84305 56639 1 76829 58966 1 69892 61200 20 54464 1 83667 56769 1 76629 58966 1 69892 61200 20 54464 1 83667 56771 1 76789 58905 1 69766 61280 21 84331 84049 56616 1 76629 58966 1 69930 61480 23 54490 1 83794 56686 1 76590 59966 1 69966 61200 24 5476 1 83296 56864 1 75913 59179 1 68979 61240 25 64664 1 83667 56769 1 76151 59101 1 69909 61520 26 64464 1 83667 56769 1 76151 59101 1 69909 61600 24 6467 64970 64970 64966 61842 618	10	.53545	1.86760	.55812	1.79174	.58124	1.72047	.60488	1.65337	50
13 53667 1.86369 55926 1.78607 58940 1.71702 6002 14 53894 1.86329 55944 1.78635 58871 1.71528 60042 15 53732 1.86109 56003 1.78563 58818 1.71473 60081 16 53792 1.86850 56079 1.78441 58887 1.71388 60721 17 58907 1.86850 56079 1.78189 58936 1.71244 60761 18 58920 1.85462 56194 1.77955 58513 1.70901 60861 21 58907 1.86838 56283 1.77784 58562 1.70767 60921 22 58986 1.85304 56270 1.77743 58851 1.70901 60861 21 58907 1.84946 56347 1.77471 58670 1.70432 6000 22 54145 1.84946 56347 1.77471 58670 1.70432 61040 </td <td>11</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>1.65228</td> <td>49</td>	11								1.65228	49
14 53894 1.86299 55964 1.7665 58879 1.71588 60642 15 53732 1.86109 56003 1.78563 58818 1.71473 60681 16 53769 1.85879 56011 1.78441 58887 1.71388 60721 17 53894 1.85730 56117 1.7819 58896 1.71244 60761 18 53844 1.85730 56117 1.78198 58435 1.71294 60761 19 53882 1.85591 56156 1.78077 58474 1.71015 60641 20 53920 1.85462 56194 1.77955 58513 1.70901 60881 21 53967 1.85893 56232 1.77785 58513 1.7097 60921 22 53965 1.85204 56270 1.77732 58513 1.70573 60960 23 54032 1.85075 56309 1.77592 58631 1.70573 60960 24 54070 1.84946 56347 1.77417 58670 1.70436 611040 25 54107 1.84818 56385 1.77351 58709 1.70582 61060 26 54145 1.84689 56424 1.77230 58787 1.70106 61160 28 54220 1.84433 56501 1.76690 58826 1.69679 61120 29 54258 1.84905 56539 1.76690 58826 1.69679 61120 20 54262 1.84433 56501 1.76690 58826 1.69679 61120 21 54333 1.84049 56616 1.76629 58965 1.69676 61240 23 54464 1.83640 56664 1.76510 58983 1.69541 61320 24 54461 1.83667 56731 1.76510 58983 1.69541 61320 25 54484 1.83540 56696 1.76510 58983 1.69541 61320 25 54461 1.83667 56731 1.76510 58983 1.69541 61360 25 54464 1.83667 56731 1.76510 58983 1.69541 61360 26 54464 1.83667 56731 1.76510 58983 1.69541 61360 26 54464 1.83667 56731 1.76510 58983 1.69541 61360 26 54461 1.83667 56769 1.75556 58297 1.66863 61440 26 54748 1.82596 56846 1.75913 59179 1.68979 61561 27 24 4.6463 1.8266 56962 1.75556 58297 1.66863 61440 26 54760 1.8256 57056 1.7580 59415 1.68906 61601 26 54760 1.8256 57155 1.7594 59256 1.6868 61601 26 54760 1.8256 57155 1.75900 59415	12			.55888		.58201	1.71817		1.65120	48 47
15					1.78685	58279	1.71588		1.65011 1.64908	46
17 53807 1.85850 56079 1.78819 58435 1.71129 6.0801 18 53844 1.85720 56117 1.78198 58435 1.71129 6.0801 19 53882 1.85432 56194 1.77075 58474 1.71015 6.0841 1.7305 58513 1.70901 6.0881 1.73057 1.85462 56194 1.77075 58513 1.70901 6.0881 1.73057 1.85832 1.85334 56232 1.777834 58852 1.70787 6.0921 2.358985 1.85034 56270 1.77713 58891 1.70673 6.0960 6.0081 4.5707 1.84046 56347 1.77792 58631 1.70560 6.1000 6.0081 6.1040 6.1		.53732				.58318			1.64795	45
18 53844 1.85730 56117 1.78198 58435 1.71199 6001 19 53882 1.85591 56156 1.78077 58474 1.71015 60841 20 58920 1.85885 56156 1.78075 58513 1.70101 60841 21 58967 1.86888 56282 1.77784 58511 1.70601 60801 22 53998 1.85075 56309 1.77792 58811 1.7050 61000 24 54070 1.84946 56347 1.77471 58670 1.70446 61040 25 54107 1.84818 56385 1.77351 58748 1.70219 61120 27 54188 1.84561 56462 1.7710 58748 1.70219 61120 29 54284 1.84905 56393 1.78690 58826 1.69982 61200 30 54296 1.84177 56377 1.76749 58905 1.69766 61280 <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>1.64687</td> <td>44</td>									1.64687	44
19									1.64579	43 42
20									1.64471 1.64363	41
22 58965 1.85074 56970 1.77713 58591 1.70573 6.0060									1.64256	40
22 58965 1.85074 56970 1.77713 58591 1.70573 6.0060	21	.58957				11		.60921	1.64148	39
24 54070 1.84946 56847 7.77471 58670 1.70446 6.01040 25 54107 1.84818 56385 1.77320 58709 1.70332 6.000 27 54183 1.84869 56424 1.77210 58778 1.70106 6.1160 28 54220 1.84433 56501 1.7690 58826 1.69992 6.1240 29 54228 1.84305 56859 1.76869 58865 1.69792 6.1240 30 54296 1.84177 56577 1.76749 58905 1.69796 6.1280 31 54333 1.84049 56616 1.76629 58946 1.69766 6.1280 32 54371 1.83924 56684 1.76390 58902 1.69428 61400 35 54446 1.83867 56731 1.76271 59061 1.69316 61400 36 54522 1.83413 56908 1.76390 59022 1.69428 <td< td=""><td>22</td><td>.53995</td><td>1.85204</td><td>.56270</td><td>1.77713</td><td>.58591</td><td>1.70673</td><td>.60960</td><td>1.64041</td><td>38</td></td<>	22	.53995	1.85204	.56270	1.77713	.58591	1.70673	.60960	1.64041	38
285 54107 1.84818 56385 1.77230 1.87809 1.70392 6.0060 28 54143 1.84689 56424 1.77230 1.87848 1.70210 6.1120 27 .54183 1.84831 .6462 1.77110 58787 1.70106 6.1160 28 .54220 1.84433 .68501 1.76990 58986 1.69699 6.1240 30 .54286 1.84177 .56577 1.76749 .58905 1.69676 .61240 31 .54383 1.84049 .56616 1.76610 .59983 1.69663 .61280 32 .54371 1.83922 .56644 1.76510 .59983 1.69663 .61420 33 .54409 1.83744 .56683 1.76300 .59022 1.64226 .61400 34 .54444 1.83667 .56731 1.76271 .59061 1.69203 .61480 36 .54522 1.83413 .56986 1.75913 .59101									1.63934	37
28 54145 1.84889 56424 1.77290 58748 1.70219 61120 27 54183 1.84561 56462 1.77110 58787 1.70106 61120 28 54220 1.84433 56501 1.76990 58826 1.69679 61240 39 54286 1.84177 56577 1.76699 58986 1.69669 61240 30 54286 1.84177 56577 1.76610 58983 1.69663 61280 32 54371 1.83922 56664 1.76610 58983 1.69663 61320 32 54471 1.83667 56731 1.76271 59061 1.69203 61440 35 54499 1.8313 56806 1.76321 59061 1.69203 61440 36 54522 1.8313 56806 1.75913 59101 1.69203 61480 37 54560 1.83286 56846 1.75913 59179 1.68920 61601 </td <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>1.70446</td> <td></td> <td>1.63826 1.63719</td> <td>36 35</td>							1.70446		1.63826 1.63719	36 35
277 54188 1.84561 56462 2.77110 55787 1.70106 61160 28 54252 1.84433 56501 1.76869 58865 1.69879 61240 30 54286 1.84177 56577 1.76749 58965 1.69879 61240 31 54383 1.84449 56616 1.76829 58944 1.60638 61320 32 .54371 1.83922 56654 1.76510 58983 1.69541 61320 33 54449 1.83794 56684 1.76810 58983 1.69541 61320 34 54446 1.83667 56731 1.76151 59101 1.69203 61440 35 54522 1.8413 56808 1.76151 59101 1.69203 61460 36 54522 1.83139 56884 1.75913 59179 1.68916 61620 37 54560 1.83296 56846 1.75913 59179 1.68916 6161					1 77290				1.63612	34
29 54288 1.84805 56839 1.76869 58965 1.66876 61240 30 54296 1.84177 56577 1.76749 58905 1.69766 61280 31 54383 1.84049 56616 1.76629 58944 1.66636 61280 32 54371 1.83922 56654 1.76510 58983 1.69541 61360 33 54409 1.83794 56683 1.76890 58922 1.69428 61400 34 54446 1.83867 56731 1.76151 59101 1.69203 61440 35 54464 1.83840 56808 1.76151 59101 1.69203 61440 36 54522 1.83413 56808 1.75791 59218 1.68879 61601 38 54597 1.83159 56885 1.75794 59218 1.68866 61601 38 54631 1.82906 66962 1.75575 59258 1.8756 658297	27	.54188				.58787			1.63505	83
Second S	28				1.76990	.58826	1.69992	.61200	1.63398	32
81 5.4383 1.84049 56616 1.76629 5.8944 1.69653 61820 32 5.4371 1.83922 56654 1.76510 58983 1.69653 61820 34 54446 1.83667 56731 1.76271 59061 1.69316 61440 35 54446 1.83540 56769 1.76151 59101 1.69203 61440 36 54522 1.83413 56806 1.7632 59140 1.69091 61520 37 54560 1.83266 56846 1.75913 59179 1.68979 61561 38 54597 1.8159 56885 1.7574 59258 1.68754 61641 40 34635 1.8206 56902 1.75575 59258 1.68754 61641 41 54711 1.82780 57009 1.75379 59376 1.68419 61721 42 3478 1.82624 57039 1.75309 59415 1.68906 61801 </td <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>1.68292</td> <td>31 30</td>									1.68292	31 30
82 54371 1.83922 56654 1.76510 58983 1.66541 61860 83 54400 1.83794 56698 1.76390 59022 1.69428 61400 84 54446 1.83607 59731 1.76271 59061 1.98316 61440 85 54484 1.83640 56769 1.76151 59101 1.98203 61480 36 54522 1.83413 56908 1.76732 59140 1.68091 61520 37 54560 1.83286 56846 1.75913 59179 1.68979 61561 38 54597 1.83159 56885 1.75774 59218 1.68966 61601 39 54635 1.8303 50923 1.75675 59258 1.68754 61601 40 54673 1.82590 57000 1.75497 59366 1.68531 61721 42 54748 1.82584 57078 1.75200 59415 1.68906 61801<								11	1.63185	
83 54409 1 83794 56698 1 76300 56922 1 66428 61400 84 54446 1 8367 56731 1 76271 59061 1 69316 61440 85 54444 1 83840 56769 1 76151 59101 1 69203 61440 36 54522 1 83438 56808 1 76032 59140 1 69091 61561 61601 38 54597 1 83159 56865 1 75794 59218 1 6866 61601 38 54597 1 8333 56923 1 75575 59258 1 61641 40 54673 1 82906 56962 1 75556 59297 1 6843 61681 61641 41 54711 1 82752 57099 1 75379 59336 1 68531 61721 42 5474									1.63079	29 28
84 54446 1.83667 56731 1.76271 59061 1.68216 61440 85 54484 1.8340 56769 1.76151 59010 1.68293 61440 86 54522 1.83413 56808 1.76032 59140 1.69091 61520 37 54500 1.83296 56846 1.75913 59179 1.88979 61561 38 54597 1.83159 56885 1.75794 59218 1.88966 61601 40 54635 1.83933 56923 1.75556 59258 1.68754 61641 40 54673 1.82960 56962 1.75556 59257 1.68643 61681 41 54711 1.82780 57000 1.75497 59376 1.86419 61721 42 54748 1.82528 57078 1.75200 59415 1.68908 61801 45 54802 1.82276 57155 1.74944 59494 1.8906 61882 </td <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>1.62972</td> <td>27</td>									1.62972	27
85 54484 1.83540 56769 1.76151 59101 1.68203 61480 36 54582 1.83413 55808 1.77613 59179 1.68979 61561 37 54560 1.83296 56846 1.75913 59179 1.68979 61561 38 54685 1.83159 56826 1.75794 59218 1.88296 61601 30 54685 1.83093 56923 1.75675 59258 1.88218 1.88296 61601 40 54673 1.82906 56962 1.75556 59297 1.68643 61641 41 54711 1.82780 57000 1.75370 59366 1.68581 61721 42 54748 1.82528 57078 1.75200 59415 1.68086 61801 44 54821 1.82402 57116 1.75062 59454 1.68086 61882 45 54802 1.82276 57155 1.74944 59494 1.680	84						1.69316		1.62760	26
37 54560 1.83266 56846 1.75913 59179 1.68679 6.1561 38 54597 1.83159 56885 1.75767 59258 1.68666 6.1601 39 .54635 1.83033 .50923 1.75675 59258 1.68754 6.1641 40 .54673 1.82806 .50902 1.75567 59258 1.68754 6.1641 41 .54711 1.82790 .57000 1.75497 59236 1.68531 61721 42 .54748 1.82528 .57078 1.75319 59376 1.68419 61721 43 .54786 1.82528 .57078 1.75300 .59415 1.68906 61801 45 54802 1.82276 .57155 1.74944 59494 1.68068 61882 46 .54900 1.82150 .57193 1.74728 59573 1.6763 61902 48 .54975 1.81899 .57232 1.74728 59573 1.6763	85				1.76151				1.62654	25
88 54597 1.83159 56885 1.75794 58218 1.68686 6.6161 89 54693 1.8903 56962 1.75556 59227 1.68643 6.1641 40 54673 1.82906 56962 1.75556 59227 1.8643 6.1641 41 54711 1.82790 57000 1.75437 58386 1.68481 6.1621 42 54748 1.82528 57078 1.75200 59415 1.68401 6.1761 43 54786 1.82528 57116 1.75020 59415 1.68419 6.1801 44 54824 1.82402 57116 1.75020 59415 1.68908 6.1801 45 54602 1.82276 57115 1.75020 59415 1.8196 6.1882 46 54900 1.82150 57133 1.74846 59533 1.67794 61922 49 55061 1.8174 57392 1.74492 59651 1.67764 6		.54522							1.62548	24 23
89 54685 1.89083 56928 1.75675 59287 1.68643 61641 40 54673 1.82906 56962 1.75556 59297 1.68643 61681 41 54711 1.82780 57009 1.75319 59376 1.68419 61761 42 .54748 1.82528 .57078 1.75319 59376 1.68419 61761 43 .54786 1.8226 .57116 1.75020 59415 1.88908 61801 44 .54824 1.82276 .57155 1.74964 59494 1.86908 61842 45 .54802 1.82276 .57155 1.74946 59494 1.69085 61982 46 .54900 1.82150 .57193 1.74926 59493 1.67863 61962 48 .54975 1.81899 1.74419 .59673 1.67643 60083 49 .55013 1.81649 .57348 1.74875 .59691 1.67752 62008									1.62442	22
41 54711 1.82780 57000 1.75487 59836 1.68581 61721 42 54748 1.82524 57078 1.75319 593676 1.68419 61761 43 54786 1.82528 57078 1.7520 59454 1.68196 61801 44 54824 1.82402 57116 1.75082 59454 1.68196 61842 45 54802 1.82276 57155 1.74964 59494 1.69065 61882 46 54900 1.82150 57133 1.74486 59533 1.67768 61982 47 54938 1.82025 57232 1.74728 59573 1.67683 61962 48 54975 1.81699 57271 1.74610 59612 1.67761 62008 49 55013 1.81649 57388 1.74875 59691 1.67761 62048 51 55069 1.81524 57386 1.74875 59730 1.67419 62214									1.62230	21
42 54748 1.82654 57039 1.75319 59376 1.68419 6.1761 43 54786 1.82528 57078 1.75200 59415 1.68196 6.1801 44 54824 1.82402 .57116 1.75082 .59454 1.68196 6.1801 45 54602 1.82276 .57155 1.74964 .59494 1.69085 6.1882 46 54900 1.82150 .57138 1.7446 .59533 1.67768 61922 47 54938 1.82025 .57232 1.7428 .59573 1.67763 69208 48 .51975 1.81899 .57271 1.74610 .59612 1.67761 62008 49 .55013 1.81649 .57388 1.74875 .59691 1.67530 62068 51 .55069 1.81524 .57886 1.74257 .59730 1.67419 62124 52 .55127 1.81399 .57425 1.74140 .59770 1.67399<	40	.54678	1.82906	.56962	1.75556	.59297	1.68643	.61681	1.62125	20
42 54748 1.82654 57039 1.75319 59376 1.68419 6.1761 43 54786 1.82528 57078 1.75200 59415 1.68196 6.1801 44 54824 1.82402 .57116 1.75082 .59454 1.68196 6.1801 45 54602 1.82276 .57155 1.74964 .59494 1.69085 6.1882 46 54900 1.82150 .57138 1.7446 .59533 1.67768 61922 47 54938 1.82025 .57232 1.7428 .59573 1.67763 69208 48 .51975 1.81899 .57271 1.74610 .59612 1.67761 62008 49 .55013 1.81649 .57388 1.74875 .59691 1.67530 62068 51 .55069 1.81524 .57886 1.74257 .59730 1.67419 62124 52 .55127 1.81399 .57425 1.74140 .59770 1.67399<			1.82780						1.62019	19
44 54824 1.82402 57116 1.75082 59454 1.68196 61842 45 54802 1.82276 57155 1.74964 59494 1.68085 61882 46 54900 1.82150 57133 1.74964 55833 1.67974 61922 47 34988 1.82025 57232 1.74728 55873 1.67683 61962 48 54975 1.81899 57271 1.74610 59612 1.67641 62048 49 55013 1.81774 57309 1.74492 59651 1.67641 62048 50 55061 1.81649 57386 1.74257 59601 1.67641 62048 51 55069 1.81524 57386 1.74257 59730 1.6741 62214 52 25127 1.81399 57425 1.74140 59770 1.67390 62164 53 55165 1.81274 57464 1.74022 59609 1.67198 62204<	42		1.82654	.57039			1.68419	.61761	1.61914	18
45 54862 1.82276 57155 1.74964 5.9494 1.66085 6.1982 46 5490 1.82150 57198 1.74846 5.5658 1.67974 6.1922 4.7 54938 1.82025 5.7232 1.74728 5.9573 1.67863 6.1962 48 5.1975 1.81899 57271 1.74610 5.95612 1.67752 6.0008 49 55011 1.81649 5.7348 1.7492 5.9651 1.67763 6.0008 6.008 5.0008 5					1.75200				1.61808	17 16
46 54900 1 82150 57198 1 74846 55838 1 67974 61922 47 54938 1 82025 57232 1 74728 59573 1 67963 61962 48 54975 1 81899 57271 1 74610 59612 1 67762 62008 49 55013 1 81774 57309 1 74492 59651 1 67641 62048 50 55061 1 81649 57348 1 74875 59691 1 67580 62068 51 55069 1 81524 57348 1 74875 59691 1 67580 62068 51 55069 1 81524 57348 1 74875 59730 1 67419 62124 52 55127 1 81399 57425 1 74140 59770 1 67300 62164 53 55165 1 81274 57464 1 74022 59609 1 67198 62204 54 55203 1 81150 57503 1 73905 59809 1 67986 62204 55 55273 1 80901 57580 1 73671 59928 1 66667 62265 55 55241 1 81025 57541 1 73788 59888 1 66978 62245 56 55279 1 80901 57580 1 73671 59928 1 66667 62255 56 55279 1 80901 57580 1 73671 59928 1 66667 62255 59 55393 1 80529 57696 1 73821 60046 1 66528 62446 62467 62566 60 55431 1 80405 57735 1 73205 60066 1 66428 62487					1.74984				1.61703 1.61598	15
47 54938 1.82025 57232 1.74728 55573 1.67683 61962 48 54975 1.81999 57271 1.74610 59612 1.677621 62008 49 55013 1.81774 .57309 1.74492 59651 1.67641 62048 50 .55061 1.81649 .57348 1.74875 .59691 1.67641 62048 51 .55069 1.81524 .57386 1.74257 .59730 1.67419 62124 52 .55127 1.81399 .57425 1.74140 .59770 1.67309 62164 53 .55127 1.81399 .57425 1.74402 .59609 1.67198 62204 54 .55230 1.81150 .57539 1.73805 .59809 1.6798 62204 54 .55231 1.80625 .57541 1.73788 .5988 1.66978 62226 56 .55271 1.80629 1.73851 .59987 1.66847 62236 <td>46</td> <td>.54900</td> <td>1.82150</td> <td>.57198</td> <td>1 74846</td> <td>.59533</td> <td>1.67974</td> <td>.61922</td> <td>1.61493</td> <td>14</td>	46	.54900	1.82150	.57198	1 74846	.59533	1.67974	.61922	1.61493	14
49 55013 1.81774 57309 1.74492 59651 1.67530 63048 50 55051 1.81649 57348 1.74875 59691 1.67530 62068 51 55069 1.81584 57386 1.74277 59730 1.67490 62124 52 .55127 1.81399 .57425 1.74140 .59770 1.67309 62264 53 .55165 1.81274 .57464 1.74022 .59809 1.67198 62204 54 .55230 1.811025 .57541 1.73788 .59888 1.66978 62285 56 .55279 1.80901 .57801 1.73671 .59928 1.66867 62325 57 .55317 1.80777 .57619 1.73355 .59967 1.6659 62406 59 .55393 1.80529 .57696 1.73321 .6006 1.66328 62446 60 .55431 1.80405 .57735 1.73205 .6006 1.66428 <td></td> <td></td> <td>1.82025</td> <td>.57232</td> <td>1.74728</td> <td></td> <td></td> <td></td> <td>1.61388</td> <td>13</td>			1.82025	.57232	1.74728				1.61388	13
50 .55061 1.81649 .57848 1.74875 .59691 1.67580 .62088 51 .55089 1.81524 .57386 1.74257 .59790 1.67419 .62124 52 .55127 1.81399 .57425 1.74140 .59770 1.67309 .62204 53 .55165 1.81274 .57464 1.74022 .59809 1.67198 .62204 54 .55203 1.81150 .57503 1.73905 .59849 1.67088 .622245 55 .55241 1.81025 .57541 1.73671 .59928 1.66867 .62226 56 .55279 1.80901 .773671 .59928 1.66867 .62226 57 .55317 1.80777 .57619 1.73555 .59967 1.67580 .62246 59 .55393 1.80529 .57696 1.73321 .60046 1.66538 .62446 60 .55431 1.80405 .57733 1.73205 .60066 1.66428				.57271					1.61283	12
51 .55069 1.81594 .57386 1.74257 .59730 1.67419 .62124 52 .55127 1.81399 .57425 1.74140 .59770 1.67399 .62164 53 .55165 1.81274 .57464 1.74022 .59809 1.67198 .62204 54 .55208 1.81150 .57503 1.73905 .59849 1.67088 .62246 55 .55241 1.81025 .57541 1.73788 .59888 1.66978 .62228 56 .55279 1.80901 .57580 1.73671 .59928 1.66867 .62328 57 .55317 1.80777 .57619 1.73355 .59967 1.66757 .62308 58 .55335 1.80653 .57657 1.73438 .60007 1.66447 .62406 59 .55338 1.80529 .57698 1.73216 .60066 1.66328 .624487 60 .55431 1.80405 .57735 1.73205 .60066									1.61179 1.61074	11 10
52 55127 1.81399 57425 1.74140 55770 1.67399 62164 53 55165 1.81274 57464 1.74022 59809 1.67198 62204 54 55203 1.81150 57503 1.7305 59899 1.67088 62246 55 55241 1.81025 57541 1.73788 59888 1.66978 622285 56 55279 1.80901 57580 1.73671 59928 1.66867 62325 57 55317 1.80777 57619 1.73355 59967 1.66757 62326 59 55335 1.80653 57657 1.73438 60007 1.66647 62406 59 55339 1.80829 57696 1.73321 60046 1.66388 62446 60 55431 1.80405 57735 1.73205 60066 1.66428 62487				100000					1.60970	9
53 55165 1 81274 57464 1 74022 59809 1 67198 62204 54 55208 1 81150 57503 1 73905 59849 1 67088 62246 55 55241 1 81025 57541 1 73788 59888 1 66973 62285 56 55279 1 80907 1 73671 99928 1 68867 63226 57 55317 1 80777 57619 1 73355 59967 1 66647 62366 58 55358 1 80529 57696 1 73321 60046 1 66438 62446 60 55431 1 80405 57733 1 73205 60068 1 66428 62446									1.60865	8
55 55241 1.81025 57541 1.73788 59688 1.66978 62285 56 55279 1.80901 57890 1.73671 59928 1.66867 62325 57 55317 1.80777 57619 1.73555 59967 1.66757 63366 58 55355 1.80633 57657 1.73438 60007 1.66647 62406 59 55398 1.80405 57735 1.73205 60066 1.66328 62446 60 55431 1.80405 57735 1.73205 60066 1.66428 62487	53	.55165	1.81274	.57464	1.74022	.59809	1.67198	62204	1.60761	7
56 .55279 1.80901 .57580 1.73671 .59928 1.66867 .62325 57 .55317 1.80777 .57619 1.73555 .59967 1.66757 .62326 58 .55855 1.80658 .57657 1.73438 .60007 1.66647 .62406 59 .55398 1.80529 .57696 1.73321 .60046 1.66328 .62446 60 .55431 1.80405 .57735 1.73205 .60066 1.66428 .62487									1.60657	6
57 55817 1.80777 57619 1.73555 59967 1.66757 62966 58 55355 1.80653 57657 1.73438 60007 1.66647 62406 59 55398 1.80529 57696 1.73231 60046 1.66528 62446 60 55431 1.80405 .57735 1.73205 .60066 1.66428 62487									1.60553	5 4
58 55855 1.80658 57657 1.73438 60007 1.66647 62406 59 55398 1.80529 57696 1.73321 60046 1.66538 62446 60 55431 1.80405 .57735 1.73205 .60066 1.66428 62486		.55317	1.80777						1.60845	8
60 .55431 1.80405 .57735 1.73205 .60086 1.66428 .62487	58	.55855	1.80653	.57657	1.73438	.60007	1.66647	.62406	1.60241	2
					1.73321		1.66538		1.60137	
, Cotang Tang Cotang Tang Cotang Tang Cotang	90								1.60033	0
	,	Cotang	rang	Cotang	Tang	Cotang	Tang	Cotang	Tang	,
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	3	2°	33	30	3	4°	3	5°	
ĽÍ	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	1
0	.62487	1.60033	.64941	1.53986	.67451	1.48256	.70021	1.42815	60
2	.62527 .62568	1.59930 1.59826	.64982 .65024	1.53888	.67493 .67536	1.48163 1.48070	.70064	1.42726 1.42638	59 58
3	.62608	1.59728	.65065	1.53693	.67578	1.47977	.70151	1.42550	57
4	.69649	1.59620	.65106	1.53595	.67620	1.47885	.70194	1.42462	56
5	.62689 .62730	1.59517 1.59414	.65148 .65189	1.53497 1.53400	.67663 .67705	1.47792 1.47699	.70238 .70281	1.42374 1.42286	55 54
7	.62770	1.59311	.65231	1.53302	.67748	1.47607	.70325	1.42198	53
8	.62811 .62852	1.59208	.65272 .65314	1.53205	.67790	1.47514	.70368	1.42110 1.42022	52
10	.62892	1.59105 1.59002	.65355	1.53107 1.53010	.67832 .67875	1.47422 1.47830	.70412 .7045 5	1.41934	51 50
11	.62933	1.58900	.65397	1.52913	.67917	1.47238	.70499	1.41847	49
12 18	.62978 .63014	1.58797 1.58695	.65438 .65480	1.52816 1.52719	.67960 .68002	1.47146 1.47053	.70542 .70586	1.41759 1.41672	48
14	.63055	1.58593	.65521	1.52622	.68045	1.46962	.70629	1.41584	46
15	.63095	1.58490	.65563	1.52525	.68088	1.46870	.70673	1.41497	45
16 17	.63136 .63177	1.58388 1.58286	.65604 .65646	1.52429 1.52332	.68130 .68173	1.46778	.70717 .70760	1.41409 1.41322	44 43
18	, 63 217	1.58184	.65688	1.52235	.68215	1.46595	.70804	1.41235	42
19 20	.63258 .63299	1.58088 1.57981	.65729 .65771	1.52139 1.52043	.68258 .68301	1.46503 1.46411	.70948 .70891	1.41148 1.41061	41 40
21	.63340	1.57879	.65813	1.51946	.68343	1.46320	.70935	1.40974	39
22	.63380	1.57778	.65854	1.51850	.68386	1.46229	.70979	1.40887	38
23	.63421	1.57676	.65896	1.51754	.68429	1.46187	.71023	1.40800	87
24 25	.63462 .63503	1.57575	.65938 .65980	1.51658 1.51562	.68471 .68514	1.46046 1.45955	.71066 .71110	1.40714	36 35
26 27	.63544	1.57372	.66021	1.51466	.68557	1.45864	.71154	1.40540	34
27	.63584 .63625	1.57271	.66063	1.51370	.68600	1.45773 1.45682	.71198	1.40454	88 82
29	.63666	1.57170 1.57069	.66105 .66147	1.51275 1.51179	.68642 .68685	1.45592	.71242 .71285	1.40281	81
30	.63707	1.56969	.66189	1.51084	.68728	1.45501	.71829	1.40195	30
31 32	.63748 .63789	1.56868	.66230 .66272	1.50988 1.50893	.68771 .68814	1.45410 1.45320	.71378 .71417	1.40109	29 28
33	.63830	1.56667	.66314	1.50797	.68857	1.45229	71461	1.39936	27
84	.63871	1.56566	.66356	1.50702	.68900	1.45139	.71505	1.39850	26
85 36	.63912 .63953	1.56466 1.56366	.66398	1.50607 1.50512	68942	1.45049 1.44958	.71549 .71598	1.39764	25 24
37	.68994	1.56265	.66482	1.50417	69028	1.44868	.71637	1.39598	23
38	.64035 .64076	1.56165	.66524	1.50322 1.50228	.69071	1.44778 1.44688	.71681 .71725	1.39507	22 21
40	.64117	1.55966	66608	1.50133	.69157	1.44598	.71769	1.39336	20
41	.64158	1.55866	.66650	1.50038	.69200	1.44508	.71813	1.89250	19
42 43	.64199 .64240	1.55766 1.55666	.66692	1.49944 1.49849	.69243 .69286	1.44418 1.44329	.71857 .71901	1.39165	18 17
44	.64281	1.55567	.66776	1.49755	.69329	1.44239	.71946	1.38994	16
45	.64822	1.55467	.66818	1.49661	.69372	1.44149	.71990	1.38909	15
46	.64363 .64404	1.55368 1.55269	.66860 .66902	1.49566 1.49472	.69416 .69459	1.44060	.72034 .72078	1.38824	14 13
48	.64446	1.55170	.66944	1.49378	69502	1.43881	.72122	1.38653	12
49 50		1.55071	.66986	1.49284	.69545	1.43792	72167	1.38508 1.38484	11 10
51	.64569		.67071	1.49097	.69631	1.43614	.72255	1.38399	9
52	.64610	1.54774	.67113	1.49003	.69675	1.43525	.72299	1.38314	8
53 54			.67155 .67197	1.48909 1.48816	.69718 .69761	1.43436 1.43347	.72344	1.38229	6
55	.64784	1.54478	.67239	1.48722	.69804	1.43258	.72432	1.38060	5
56 57			.67282 .67324	1.48629 1.48536	.69847 .69891	1.43169 1.43080	.72477	1.37976	8
58	.64817 .64858		.67366	1.48536	.69934	1.43080	72565	1.37891	2
59 60	.64899	1.54085	.67409	1.48349 1.48256	.69977	1.42908 1.42815	.72610 .72654	1.87722 1.87688	1
20	.64941 Cotans		.67451 Cotang		.70021 Cotang		Cotang		- '
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34 74176 1.34814 76918 1.30009 79734 1.25417 83629 1.21028 35 74297 1.34650 77010 1.29853 79829 1.25268 82727 1.20879 36 74207 1.34650 77010 1.29853 79829 1.25268 82727 1.20879 37 74312 1.34687 77103 1.29696 79924 1.25193 82776 1.20869 39 74402 1.34405 77149 1.29618 79972 1.25044 82874 1.2068 40 74447 1.34323 77196 1.29641 80020 1.24969 82928 1.20569 41 74492 1.34242 777242 1.2963 80020 1.24895 82972 1.2063 43 74538 1.34160 77289 1.29229 80211 1.24820 83022 1.20451 44 74628 1.33988 77382 1.29229 80211 1.24672 83120					1 30087			82580		28 27
86 74987 1. 34650 .77010 1. 29858 79929 1. 25988 82727 1. 29679 37 74312 1. 34568 .77057 1. 29775 .79877 1. 25193 82776 1. 29068 38 74357 1. 34467 .77103 1. 29618 .79972 1. 25044 82825 1. 20736 39 74402 1. 34405 .77149 1. 29618 .90020 1. 24604 82874 1. 20683 41 74492 1. 34242 .77242 1. 29463 .80067 1. 24895 .82972 1. 20583 42 74538 1. 34160 .77289 1. 29385 .80115 1. 24820 .83022 1. 20522 42 74538 1. 34079 .77335 1. 29229 .80211 1. 24672 .83120 1. 20379 45 74674 1. 33916 .77428 1. 29152 .80258 1. 24572 .83169 1. 20379 46 74719 1. 33355 .77457 1. 28997 .8036	34	.74176	1.34814	.76918	1.30009		1.25417	.82629		26
87 74312 1 34568 77057 1 29775 70877 1 25103 82776 1 29096 38 74357 1 34487 77103 1 29696 79924 1 25118 83825 1 20736 39 74402 1 34405 77149 1 29618 79972 1 25044 88874 1 29665 40 74447 1 34323 77196 1 29461 80020 1 24969 82923 1 29665 41 74492 1 34242 77242 1 29463 80020 1 24895 82972 1 20522 42 74538 1 34160 77289 1 23985 80115 1 24820 83022 1 20451 43 74583 1 34079 77335 1 23907 80163 1 24746 83071 1 20306 44 74628 1 33996 77382 1 20229 80211 1 24672 83120 1 20306 45 74674 1 33916 77428 1 29152 80258 1 24597 83169 1 20227 46 7479 1 33835 77475 1 29074 80306 1 24523 83201 20066 47 74764 1 33754 77521 1 28997 80354 1 2449 83263 1 20026 48 74810 1 33873 77568 1 28919 80402 1 24875 83169 1 20227 49 74855 1 33592 77661 1 28842 80498 1 2449 83263 1 20095 50 74900 1 33511 77661 1 28764 80498 1 24227 83120 1 19953 50 74901 1 3349 77708 1 28687 80546 1 24153 83465 1 19953 51 74946 1 3349 77754 1 28610 80498 1 24227 83151 1 19953 53 75037 1 33268 77601 1 28832 80642 1 24079 83514 1 19740 53 75087 1 33369 77768 1 28859 80642 1 24079 83514 1 19740 53 75087 1 33368 77601 1 28339 80642 1 24005 83564 1 19852 55 75128 1 33107 77885 1 28579 80788 1 28889 8363 1 19882 56 75173 1 33946 77985 1 28379 80788 1 28784 88712 1 19859 57 75310 1 32785 78035 1 28148 80882 1 23867 8861 1 19836 60 75355 1 32704 78129 1 27994 80978 1 23490 83910 1 19175 Cotang Tang Cotang Tang Cotang Tang Cotang Tang Cotang Tang										25
38 74357 1.34487 .77103 1.29696 .79924 1.25118 88285 1.20736 39 74402 1.34405 .77149 1.29618 .79924 1.25044 82874 1.20665 40 74447 1.34323 .77196 1.29541 .80020 1.24896 82928 1.20638 41 74492 1.34242 .77242 1.29463 .80067 1.24895 82972 1.20522 42 .74583 1.34160 .77289 1.29385 .80115 1.24820 .89022 1.20529 44 .74628 1.33096 .77332 1.20229 .80211 1.24672 .83120 1.20379 44 .74628 1.33916 .77428 1.29152 .80258 1.24672 .83120 1.20287 45 .74674 1.33916 .77428 1.29152 .80258 1.24672 .83120 1.20287 46 .74719 1.33835 .77475 1.28977 .80364 1.24449 .83268 1.20287 48 .74850 1.33517 .77661<										24 23
40 .74447 1.34323 .77196 1.29541 .80020 1.24969 .82928 1.20693 41 .74492 1.34242 .77242 1.29463 .80067 1.24895 .83972 1.20593 42 .74583 1.34079 .77335 1.23937 .80163 1.24630 .83922 1.20321 43 .74583 1.34079 .77335 1.23307 .80163 1.24746 .83071 1.20379 44 .74482 1.33998 .77382 1.20229 .80211 1.24672 .83169 1.20379 45 .74674 1.33916 .77428 1.29152 .80288 1.24597 .83169 1.20227 46 .74719 1.33835 .776521 1.28997 .80364 1.24452 .83281 1.20122 48 .74610 1.33873 .77561 1.28842 .80460 1.24375 .83317 1.20024 49 .74855 1.335922 .7661 1.28874 .80480	38			.77103	1.29696		1.25118	82825		22
41 74492 1.34242 77942 1.29463 .80067 1.24895 82972 1.20522 42 74538 1.34160 777289 1.29385 80115 1.24820 83022 1.20451 43 74588 1.34979 .77335 1.29307 80163 1.24746 83071 1.20379 44 74628 1.33998 77382 1.29229 80211 1.24672 83120 1.20308 45 74674 1.33916 77428 1.29152 80258 1.24597 83169 1.20208 46 74719 1.33835 .77475 1.29074 80306 1.24523 83218 1.20166 47 74764 1.33754 .77521 1.28997 80384 1.2449 83268 1.20026 48 74810 1.33673 77568 1.28919 80420 1.24527 83169 1.20224 49 74855 1.33592 77615 1.28942 80450 1.24501 83366 1.20524 49 74856 1.33592 77615 1.28842 80450 1.24901 83366 1.29024 50 74900 1.33511 77661 1.28764 80498 1.24277 83415 1.19852 51 74946 1.33430 77708 1.28867 80546 1.24153 83415 1.19852 52 74991 1.33349 77754 1.28610 80544 1.24079 83514 1.19740 53 75087 1.33988 77901 1.28833 80642 1.24005 83564 1.19671 53 75087 1.33936 77901 1.28833 80642 1.24005 83564 1.19671 54 75082 1.33107 777845 1.28501 80642 1.24005 83564 1.19859 55 75128 1.33107 777845 1.28500 80644 1.24079 83514 1.19740 53 75087 1.32986 77901 1.28833 80642 1.24005 83564 1.19695 55 75128 1.33107 777845 1.28500 80644 1.24079 83514 1.19740 53 75082 1.33187 77848 1.28456 80690 1.23931 83613 1.19599 55 75128 1.33107 77885 1.28379 80738 1.28858 83663 1.19659 55 75128 1.33107 77885 1.28379 80738 1.28389 83663 1.19528 56 75173 1.382026 77941 1.28302 80786 1.23710 83761 1.19387 58 75350 1.32785 78082 1.28148 80882 1.23637 83811 1.19387 58 75350 1.32785 78082 1.28148 80882 1.23637 83811 1.19317 58 75350 1.32785 78082 1.28148 80882 1.23637 83811 1.19317 50 75350 1.32785 78082 1.28148 80882 1.23637 83811 1.19317 50 75350 1.32785 78082 1.28148 80882 1.23637 83811 1.19317					1.29618					21
43		*******		111111				1		20
48										19 18
44 74628 1 33998 77382 1 29229 80211 1 24672 83120 1 20308 45 74674 1 33916 77428 1 39152 80286 1 24597 83169 1 20287 46 74719 1 33835 77475 1 29074 80306 1 24523 83218 1 20168 47 74764 1 33754 77521 1 28997 80354 1 24449 83268 1 20068 48 74810 1 33673 77568 1 28919 80450 1 24527 83317 1 20024 49 74855 1 33592 77615 1 28842 80450 1 24301 83366 1 29054 1 24500 1 33511 77661 1 28764 80498 1 24227 83415 1 20084 1 24500 1						.80163				17
46						.80211		.83120		16
48							1.24597			15
48								83268		14 13
50 74900 1.38511 .77661 1.28764 .80498 1.24227 .88415 1.19882 51 .74946 1.33430 .77708 1.28867 .80546 1.24153 .83465 1.19611 52 .74991 1.33368 .777801 1.28810 .80694 1.24079 .83514 1.19740 53 .75087 1.33368 .77801 1.28533 .80642 1.24005 .83564 1.19669 54 .75082 1.33107 .77848 1.28379 .80788 1.28981 .8963 1.19599 55 .75128 1.33107 .77941 1.28302 .80786 1.28794 .83712 1.19457 57 .75219 1.32946 .77981 1.28225 .80834 1.28710 .83761 1.19887 58 .75384 1.32865 .78085 1.28148 .80823 1.2363 .83961 1.19316 59 .75310 1.32704 .78129 1.28794 .80978 1.23490 .83910 1.19175 Cotang Tang Cotang	48	.74810	1.33673	.77568	1.28919	.80402	1.24375	.83317	1.20024	12
51 74946 1.33430 .77708 1.28687 .90546 1.24153 .83465 1.19811 52 7.4991 1.33349 .77754 1.28610 .80594 1.24079 .83514 1.19740 53 .75087 1.33268 .77801 1.28533 .80642 1.24005 .83564 1.19669 54 .75082 1.33187 .77848 1.28456 .90690 1.23891 .83618 1.19599 55 .75128 1.33107 .77845 1.28579 80788 1.22858 .89663 1.19529 56 .75173 1.39026 .77941 1.28902 .80786 1.23780 83761 1.19827 57 .75219 1.32946 .77986 1.28225 .90834 1.28710 .83761 1.19827 58 .75264 1.32785 .78082 1.28071 .80930 1.23637 .89811 1.19316 59 .75355 1.32704 .78129 1.27994 .80978 1.23490 .80910 1.19175 Cotang Tang Cotang T										11
52 74991 1, 33349 77754 1, 28610 80694 1, 24079 85314 1, 19740 53 75082 1, 33187 77848 1, 28456 80642 1, 24005 83564 1, 19669 54 75082 1, 33187 77848 1, 28456 80642 1, 28351 83618 1, 19539 55 75128 1, 33107 77895 1, 28379 80788 1, 22858 83663 1, 19539 56 75173 1, 33026 77941 1, 28302 80786 1, 23784 83712 1, 19457 57 75219 1, 32946 77988 1, 28255 80636 1, 23784 83712 1, 19457 58 75240 1, 132785 78035 1, 28148 80882 1, 28637 83811 1, 19316 60 75355 1, 32704 78129 1, 27994 8078 1, 23490 83910 1, 19175 75 7500 7500 7500 7500 7500 7500 750	1			11	1	11	1	100000		10
53 . 75087 1.33268 .77801 1.28533 .80642 1.24005 .83564 1.19669 54 . 75062 1.33187 .77848 1.28456 .80690 1.23931 .83618 .18599 .55 . 75128 1.33107 .77895 1.28379 .80788 1.28858 .8363 1.19528 .56 . 75173 1.33026 .77941 1.28302 .80786 1.23784 .83712 1.19528 .57 . 75219 1.32946 .77988 1.28225 .80834 1.23710 .83761 1.19387 .58 . 75364 1.32785 .78035 1.28148 .80882 1.23337 .83811 1.19316 .59 . 75310 1.32785 .78082 1.28701 .80930 1.23563 .83801 1.19175 .78 . 78 . 78 . 78 . 78 . 78 . 78 . 7										8
54 75062 1 33187 77848 1 .28456 80690 1 .28981 83618 1 .13595 55 75128 1 .33107 .77895 1 .28379 80738 1 .28856 89683 1 .19528 56 .75173 1 .39346 .77981 1 .28802 .80786 1 .28748 83712 1 .19457 57 .75219 1 .39346 .77988 1 .28225 .80834 1 .28710 83761 1 .19837 58 .75344 1 .32785 .78085 1 .28148 80882 1 .2837 83811 1 .19316 59 .75350 1 .32704 .78129 1 .27994 .80978 1 .23490 .83910 1 .19175 Cotang Tang Cotang Tang Cotang Tang Cotang Tang				.77801						7
56 .75173 1.83026 .77941 1.28302 .80786 1.28784 .88712 1.19457 57 .75219 1.32946 .77988 .1.28225 .80834 1.22710 .83761 1.19387 58 .75264 1.32865 .78085 1.28148 .80822 1.2363 .83811 1.19316 59 .75310 1.32785 .78082 1.28071 .80930 1.23563 .83960 1.19246 60 .75355 1.32704 .78129 1.27994 .80978 1.23490 .83910 1.19175 Cotang Tang Cotang Tang Cotang Tang Cotang Tang	54	.75082	1.33187	.77848	1.28456	.80690	1.23931	.83618	1.19599	6
57 .75219 1.38946 .77988 1.28225 .80634 1.28710 .83761 1.19387 58 .75264 1.32865 .78035 1.28148 .80882 1.22637 .83811 1.19316 59 .75310 1.32785 .78082 1.28071 .80930 1.23663 .83860 1.19246 60 .75355 1.32704 .78129 1.27994 .80978 1.23490 .89910 1.19175 Cotang Tang Cotang Tang Cotang Tang Cotang Tang										5
58 .75264 1.32865 .78085 1.28148 .80882 1.23637 .83811 1.19316 59 .75310 1.32785 .78082 1.28071 .80930 1.23663 .83860 1.19246 60 .75355 1.32704 .78129 1.27994 .80978 1.23490 .83910 1.19175 Cotang Tang Cotang Tang Cotang Tang Cotang Tang									1.19907	3
59 .75810 1.32785 .78082 1.28071 80930 1.2363 88860 1.19246 60 .75355 1.32704 .78129 1.27994 .80978 1.23490 .83910 1.19175 Cotang Tang Cotang Tang Cotang Tang Cotang Tang	58	.75264	1.32865	.78035	1.28148	.80882	1.23637	83811	1.19316	8 2 1
Cotang Tang Cotang Tang Cotang Tang Cotang Tang					1.28071					1
	100			!				·		. 0
· 53° 52° 51° 50°	1.	-	<u> </u>		'		'	·		
	•	1 1	53°	11	2°	11 6	51°	l! 	0°	1

TABLE III.—NATURAL TANGENTS AND COTANGENTS.

[,]	4	.0°	4	1°	4	2°	4	. 3 °	,
'	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	1
0	.83910	1.19175	.86929	1.15087	.90040	1.11061	.93252	1.07287	60
1	.83960	1.19105	.86980	1.14969	.90098	1.10996	.93306	1.07174	59
2 3	.84009 .84059	1.19035 1.18964	.87031 .87082	1.14902 1.14884	.90146 .90199	1.10931 1.10867	.93360	1.07112	58 57
4	.84108	1.18894	.87133	1.14767	.90251	1.10802	.93469	1.06987	56
5	.84158	1.18824	.87184	1.14699	.90304	1.10737	.93524	1.06925	55
6	.84208	1.18754	.87236	1.14682	.90357	1.10672	.98578	1.06862	54
7	.84258	1.18684	.87287	1.14565	.90410	1.10607	.93633	1.06800	53
8	.84307 .84357	1.18614 1.18544	.87338 .87389	1.14498 1.14430	.90468 .90516	1.10543 1.10478	.93688 .98742	1.06788	52 51
10	84407	1.18474	.87441	1.14368	.90569	1.10414	.98797	1.06613	50
11	.84457	1.18404	.87492	1.14296	.90621	1.10849	.93852	1.06551	49
12	.84507	1.18334	.87543	1.14229	.90674	1.10285	.98906	1.06489	48
13	.84556 .84606	1.18264 1.18194	.87595 .87646	1.14162 1.14095	.90727	1.10220 1.10156	.98961	1.06427	47
14 15	.84656	1.18125	.87698	1.14028	.90834	1.10136	.94071	1.06308	45
16	.84706	1.18055	.87749	1.13961	.90887	1.10027	.94125	1.06241	44
17	.84756	1.17986	.87801	1.18894	.90940	1.09963	.94180	1.06179	43
18	.84306	1.17916	.87852	1.13828	.90993	1.09899	.94235	1.06117	42
19 20	.84856 .84906	1.17846 1.17777	.87904 .87955	1.13761 1.13694	.91046 .91099	1.09834	.94290	1.06056 1.05994	41 40
21	.84956	1.17708	.88007	1.18627	.91153	1.09706	.94400	1.05982	39
22	.85006	1.17638	.88059	1.18561	.91206	1.09642	.94455	1.05870	88
23	.85057	1.17569	.88110	1.18494	.91259	1.09578	.94510	1.05809	87
24	.85107	1.17500	.88162 .88214	1.13428	.91813	1.09514	.94565	1.05747	36
25 26	.85157 .85207	1.17430 1.17361	.88265	1.18361 1.18295	.91366 .91419	1.09450 1.09386	.94620	1.05685	85 84
27	85257	1.17292	.88317	1.13223	.91473	1.09322	.94781	1.05562	33
28	85308	1.17223	.88369	1.13162	.91526	1.09258	.94786	1.05501	32
29	.85358	1.17154	.88421	1.13096	.91580	1.09195	.94841	1.05439	81
30	.85408	1.17085	.88473	1.13029	.91633	1.09181	.94896	1.05378	30
81 82	.85458 .85509	1.17016 1.16947	.88524 .88576	1.12963 1.12897	.91687	1.09067 1.09003	.94952	1.05317 1.05255	29
83	.85559	1.16878	.88628	1.12831	.91794	1.08940	.95062	1.05194	28 27
84	.85609	1.16809	.88680	1.12765	.91847	1.08876	.95118	1.05133	26
85 86	.85660	1.16741	.88732	1.12699	.91901	1.08813	.95178	1.05072	25
86	.85710	1.16672	.88784 .88836	1.12688	.91955	1.08749	.95229	1.05010	24
87 88	.85761 .85811	1.16603 1.16535	.88888	1.12567 1.12501	.92008	1.08686 1.08622	.95284	1.04949	23 22
39	.85862	1.16466	.88940	1.12435	.92116	1.08559	.95395	1.04827	21
40	.85912	1.16398	.88992	1.12369	.92170	1.08496	.95451	1.04766	20
41	.85963	1.16329	.89045	1.12308	.92224	1.08432	.95506	1.04705	19
42	.86014	1.16261	.89097	1.12238	.92277	1.08369	.95562	1.04644	18
43	.86064 .86115	1.16192 1.16124	.89149 .89201	1.12172	.92331	1.08306	.95618 .95673	1.04588	17 16
45	.86166	1.16056	.89253	1.12041	.92439	1.08179	.95729	1.04522	15
46	.86216	1.15987	.89306	1.11975	.92493	1.08116	.95785	1.04401	14
47	.86267	1.15919	.89358	1.11909	.92547	1.08053	.95841	1.04340	13
48	.86318	1.15851	.89410	1.11844	.92601	1 07990	.95897	1.04279	12
49 50	.86368 .86419	1.15788 1.15715	.89463 .89515	1 11778 1.11713	.92655	1.07927 1.07864	.95952 .96008	1.04218 1.04158	11 10
51	.86470	1.15647	.89567	1.11648	.92763	1.07801	.96064	1.04097	9
52	.86521	1.15579	.89620	1.11582	.92817	1.07738	.96120	1.04036	8
53 54	.86572 .86623	1.15511	.89672 .89725	1.11517 1.11452	.92926	1.07676 1.07613	.96176 .96232	1.03976 1.03915	6
55	.86674	1.15375	.89777	1.11387	.92980	1.07550	.96288	1.03855	5
56	.86725	1.15308	.89830	1.11321	.93034	1.07487	.96844	1.03794	4
57	.86776	1.15240	.89883	1.11256	.93088	1.07425	.96400	1.03784	8
58 59	.86827	1.15172	.89935	1.11191	.93143	1.07362	.96457	1.03674	2
60	.86878 .86929	1.15104 1.15037	.90040	1.11126 1.11061	.93197 .93252	1.07299 1.07237	.96513 .96569	1.08618 1.08558	ō
1,	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	-
1	1 4	19°	4	8°	4	7°	4	6°	'

TABLE III.—NATURAL TANGENTS AND COTANGENTS.

	1 4	4 °	1	()	1	140	7	11	1 4	40	
		F2*		١,	I	4 °		H ,		4°	
_	Tang	Cotang			Tang	Cotang		`	Tang	Cotang	
0	.96569	1.03553	60	20	.97700	1.02855	40	40	.98843	1.01170	90
1	.96625	1.03498	59	21	.97756	1.02295	39	41	.98901	1.01112	19
2	.96681	1.03433	58	22	.97813	1.02236	38	42	.98958	1.01053	18
8	.96788	1.03372	57	23	.97870	1.02176	37	43	.99016	1.00994	17
4	.96794	1.03312	56	24	.97927	1.02117	36	44	.99073	1.00935	16
5	.96850	1.03252	55	25	.97984	1.02057	35	45	.99131	1.00876	15
6	.96907	1.03192	54	26	.98041	1.01998	34	46	.99189	1.00818	14
7	.96963	1.03132	53	27	.98098	1.01939	33	47	.99247	1.00759	13
8	.97020			28	.98155	1.01879	32	48	.99304	1.00701	12
9	.97076	1.03012	51	29	.98213	1.01820	31	49	.99362	1.00642	11
10	.97133	1.02952	50	30	.98270	1.01761	30	50	.99420	1.00583	10
11	.97189	1.02892	49	81	.98327	1.01702	29	51	.99478	1.00525	9
12	.97246	1.02832	48	82	.98384	1.01642	28	52	.99536	1.00467	8
13	.97302	1.02772	47	83	.98441	1.01583	27	53	.99594	1.00408	7
14	.97359	1.02718	46	84	.98499	1.01524	26	54	.99652	1.00350	- 6
15	.97416	1.02658	45	35	.98556	1.01465	25	55	.99710	1.00291	5
16	.97472	1.02593	44	36	.98613	1.01406	24	56	.99768	1.00233	4
17	.97529	1.02533	43	37	.98671	1.01347	23	57	.99826	1.00175	8
18	.97586	1.02474	42	38	.98728	1.01288	22	58	.99884	1.00116	2
19	.97643	1.02414	41	39	.98786	1.01229	21	59	.99942	1.00058	l ĩ l
20	.97700	1.02355	40	40	.98843	1.01170	20	60	1.00000	1.00000	ō
	Cotang	Tang	_	_	Cotang	Tang	_	_	Cotang	Tang	_
	45°			<u> </u>	4	5°			4	5•	

TABLE IV.-NATURAL VERSED SINES AND EXTERNAL SECANTS

	()•		l°	1	3.	;	3°	
'	Vers.	Ex. sec.	Vers.	Ex. sec.	Vers.	Ex. sec.	Vers.	Ex. sec.	′
0	.00000	.00000	.00015	.00015	.00061	.00061	.00137	.00137	0
1 2	.00000	.00000	.00016	.00016 .00016	.00062	.00062	.00139	.00139	1
8	.00000	.00000	.00017	.00016	.00064	.00064	.00140	.00140	2 3 4 5 6 7 8
4	.00000	.00000	.00017	.00017	00065	.00065	.00148	.00143	4
4 5 6 7 8	.00000	.00000	.00018	.00018	.00066 .00067	.00066	.00145	.00145	5
9	.00000	.00000	.00018	.00018	.00068	.00067	.00146	.00147	6
8	.00000	.00000	.00020	.00020	.00069	.00069	.00150	.00150	8
9	.00000	.00000	.00020	.00020	.00070	.00069	.00151	.00151	9
10	.00000	.00000	.00021	.00021	.00071	.00072	.00158	.00153	10
11	.00001	.00001	.00021	.00021	.00078	.00078	.00154	.00155	11
12 13	.00001 .00001	.00001 .00001	.00023	.00022	.00074	.00075	.00156	.00156	12 13
14	.00001	.00001	.00028	.00023	.00076	.00076	.00159	.00159	14
15	.00001	00001	.00024	.00024	.00077	.00077	.00161	.00161	15
16 17	.00001	.00001 .00001 .00001	.00024	.00024 .00025	.00078	.00078	.00162	.00163	16
18	.00001	.00001	.00023	.00025	000019	.00081	.00166	.00166	17 18
19	.00002	.00002	.00026	.00026	.00081	.00081	.00168	.00168	19 20
20	.00002	.00002	.00027	.00027	.00083	.00083	.00169	.00169	20
21	.00002	.00002	.00028	.00028	.00084	.00084	.00171	.00171	21
22	.00002	.00002	.00028	.00028	.00085	.00085	.00178	.00178	22
23	.00002	.000002	.00029	.00029 .00030	.00087	.00087	.00174 .00176	.00175	23 24
25	.00003	.00002	.00031	.00031	.00089	.00089	.00178	.00178	25
26	.00003	1 000003	.00031	.00031	.00090	.00090	.00179	.00180	25 26
27	.00003	.00008	.00032	.00032	.00091	.00091	.00181	.00182	27
24 25 26 27 28 28 28 28 28 28 28 28 28 28 28 28 28	.00003	.00008 .00008 .00004	.00033	.00033 .00034	.00094	.00094	.00185	.00185	27 28 29 20
30	.00004	.00004	.00034	.00034	.00095	.00095	.00187	.00187	80
31	.00004	.00004	.00085	.00035	.00096	.00097	.00188	.00189	81
32	.00004	.00004	.00036	.00036	.00098	.00098	.00190	.00190	32
33 34	.00005	.00005	.00037	.00037	.00099	.00099	.00192 .00194	.00192	83 84
35	.00005	.00005	.00038	00038	.00102	.00102	.00196	.00196	35
36	.00005	00005	.00038	.00039	.00108	.00103	.00197	.00198	36 87
87	.00006 .00006	.00006	.00040	.00040 (.00104	.00104	.00199	.00200	87
88 89	.00006	.00006 .00006	.00041	.00041	.00107	.00106	.00201	.00201	88 39
40	.00007	.00007	.00042	.00042	.00108	.00108	.00205	.00205	40
41	.00007	.00007	.00043	.00048	.00110	.00110	.00207	.00207	41
42	.00007	.00007	.00044	.00044	.00111	.00111	.00208	.00209	42
43 44	.00008 .00008	.00008	.00045	.00045	.00112	.00113	.00210	.00211	48
45	.00009	.00009	.00047	.00047	.00115	.00115	.00214	.00215	45
46	.00009	.00009	.00048	.00048	.00117	.00117	.00216	.00216	46
47	.00009	.00009	.00048	.00048	.00118 .00119	.00118	.00218	.00218	47 48
48 49	.00010	.00010	.00019	.00050	.00121	.00120	.00222	.00222	49
50	.00011	.00011	.00051	.00051	.00122	.00122	.00224	.00224	50
51	.00011	.00011	.00052	.00052	.00124	.00124	.00226	.00226	51
52	.00011	.00011	.00053	.00058	.00125	.00125	.00228	.00228	52
52 53 54 55 55 56 57	.00012	.00012	.00054	.00054	.00127	.00127	.00230	.00230	58 54
55	.00012	1.00013	.00056	.00056	.00128	.00120	.00284	.00234	55
56	.00018	.00018	.00057	.00057	.00131	.00131	.00236	.00236	55 56 57 58
57	.00014 .00014	.00014	.00058	.00058	.00188	.00183 .00184	.00238	.00238	57
58 59 60	.00014	.00014	.00060	.00060	.00134	.00134	.00242	.00240	59
60	.00015	.00015	.00061	.00061	.00137	.00137	.00244	.00244	60

,	4	40	,	5°		B°	,	7°	
•	Vers.	Ex. sec.	Vers.	Ex. sec.	Vers.	Ex. sec.	Vers.	Ex. sec.	,
0	.00244	.00244	.00381	.00382	.00548	.00551	.00745	.00751	0
1	.00248	.00246	.00383	.00385	.00551	.00554	.00749	.00755	1
2 8	.00250	.00250	.00388	.00390	.00557	.00560	.00756	.00762	2 8
4	.00252	.00252	.00391	.00392	.00560	.00563	.00760	.00765	1
4	.00254	.00254	.00393	.00395	.00563	.00566	.00763	.00769	4 5 6
6	.00256	.00257	.00396	.00397	.00566	.00569	.00767	.00773	6
7	.00258	.00259	.00398	.00400	.00569	.00573	.00770	.00778	7
8	.00260	.00261	.00401	.00408	.00572	.00576	.00774	.00780	8
9	.00262	.00263	.00404	.00405	.00576	.00579	.00778	.00784	ğ
10	.00264	.00265	.00406	.00408	.00579	.00582	.00781	.00787	10
11 12	.00266	.00267	.00409	.00411	.00582	.00585	.00785	.00791	11
18	.00209	.00209	.00412	.00418	.00585	.00588	.00789	.00795	12 13
14	.00271	.00271	.00414	.00416	.00588	.00592	.00792	.00799	18 14
15	.00275	.00278	.00420	.00421	.00594	00598	.00800	.00808	15
16	.00277	.00278	.00422	.00424	.00598	.00601	.00808	.00810	16
17	.00279	.00280	.00425	.00427	.00601	.00604	.00807	.00813	17
18	.00281	.00282	.00428	.00429	.00604	.00608	.00811	.00817	18
19	.00284	.00284	.00430	.00432	.00607	.00611	.00814	.00821	19
20	.00286	.00287	.00438	.00435	.00610	.00614	.00818	.00825	20
21	.00288	.00289	.00436	.00438	.00614	.00617	.00822	.00828	21
22	.00290	.00291	.00438	.00440	.00617	.00621	.00825	.00832	22
23	.00293	.00293	.00441	.00443	.00620	.00624	.00029	.00836	23
24	.00295	.00296	.00444	.00446	.00623	.00627	.00883	.00840	24
20	.00297	.00298	.00447	.00449	.00626	.00630	.00887	.00844	25 26 27
97	.00299	.00300	.00449 .00452	.00451	.00630	.00634	.00840	.00848	20
28	.00304	.00305	.00455	.00457	.00636	.00640	.00848	.00855	96
29	.00306	.00307	.00458	.00460	.00640	.00644	.00852	.00859	90
22 23 24 25 26 27 28 29 80	.00308	.00309	.00460	.00463	.00643	.00647	.00856	.00863	28 29 30
81	.00311	.00312	.00468	.00465	.00646	.00650	.00859	.00867	31
82	.00313	.00814	.00466	.00468	.00649	.00654	.00863	.00871	32 33
83	.00315	.00316	.00469	.00471	.00653	.00657	.00867	.00875	33
84	.00317	.00318	.00472	.00474	.00656	.00660 .00664	.00871	.00878	34 85
85 86	.00320 .00322	.00321	.00474	.00477	.00659	.00667	.00875	.00882	85
87	.00324	.00326	.00480	.00400	.00666	.00671	.00882	.00890	86 87
88	.00327	.00328	.00483	.00482	.00669	.00674	.00886	.00894	38
89	.00329	.00330	.00486	.00488	.00678	.00677	.00890	.00898	39
40	.00332	.00333	00489	.00491	.00676	.00681	.00894	.00902	40
41	.00334	.00335	.00492	.00494	.00680	.00684	.00898	.00906	41
42	.00336	.00337	.00494	.00497	.00683	.00688	.00902	.00910	42
43	.00339	.00340	.00497	.00500	.00686	.00691	.00906	.00914	43
44	.00341	.00342	.00500	.00503	.00690	.00695	.00909	.00918	44
45 46	.00348	.00345	.00508	.00506	.00693	.00698	.00918	.00922	45
47	.0034 6 .00348	.00347	.00506	.00509	.00697	.00701	.00917	.00926	46
48	.00348	.00352	.00509	.00512	.00700	.00705	.00921	.00930	47 48
49	.00353	.00354	.00512	.00518	.00707	.00712	.00929	.00938	49
50	.00356	.00857	.00518	.00521	.00710	.00715	.00933	.00942	50
51	.00358	.00359	.00521	.00524	.00714	.00719	.00937	.00946	51
52	.00361	.00362	.00524	.00527	.00717	.00722	.00941	.00950	52 58
58	.00363	.00364	.00527	.00530	.00721	.00726	.00945	.00954	58
54	.00365	.00367	.00530	.00533	.00724	.00730	.00949	.00958	54
00	.00368	.00369	.00533	.00536	.00728	.00788	.00953	.00962	55
55 56 57	.00370	.00372	.00536	.00539	.00731	.00737	.00957	.00966	54 55 56 57
58	.00378	.00374	.0053 9 .0054 2	.00542	.00735	.00740 .00744	.00961	.00970	07
59	.00378	.00379	.00542	.00548	.00788	.00747	.00969	.00979	58 59 60
~	.00381	.00382	.00548	.00551	.00745	.00751	.00978	.00983	

TABLE IV .- NATURAL VERSED SINES AND EXTERNAL SECANTS

,		•)•	10	0°	1	1•	,
	Vers.	Ex. sec.	Vers.	Ex. sec.	Vers.	Ex. sec.	Vers.	Ex. sec.	
0	.00978	.00988	.01281	.01247	.01519	.01548	.01837	.01872	0
1 1	.00977	.00987	.01286	.01251	.01524	.01548	.01848	.01877	1 2 8 4 5 6 7 8
2 8	.00981	.00991	.01240 .01245	.01256 .01261	.01529 .01584	.01558	.01848	.01883 .01889	8 8
4	.00989	.00999	.01249	.01265	.01540	.01564	.01860	.01895	4
5	.00994	.01004	.01254	.01270	.01545	.01569	.01865	.01901	5
5	.00998	.01008	.01259	.01275	.01550	.01574	.01871 .01876	.01906	6
8	.01002	.01018	.01268	.01284	.01560	.01585	.01882	.01918	8
9	.01010	.01020	.01272	.01289	.01565	.01590	.01888	.01924	9
10	.01014	.01024	.01277	.01294	.01570	.01595	.01898	.01980	10
11	.01018	.01029	.01282	.01298	.01575	.01601	.01899	.01936	11
12 18	.01022	.01088	.01286 .01291	.01303	.01580 .01586	.01606 .01611	.01904 .01910	.01941	12 13
14	.01031	.01041	01996	.01318	.01591	.01616	.01916	.01958	14
15	.01035	.01046	.01800 .01805 .01810	.01318	.01596	.01622	.01921	.01959	15
16	.01039	.01050	.01305	.01822	.01601	.01627	.01927	.01965	16
17 18	.01043 .01047	.01054 .01059	.01814	.01327	.01606 .01612	.01688 .01688	.01983 .01989	.01977	17 18
19	.01052	.01068	.01819	.01337	.01617	.01648	.01944	.01983	19
20	.01056	.01067	.01824	.01842	.01622	.01649	.01950	.01989	20
21	.01060	.01071	.01829	.01846	.01627	.01654	.01956	.01995	21
223 23	.01064	.01076	.01838	.01851	.01682	.01659	.01961	.02001	22
	.01069	.01080 .01084	.01888	.01856 .01861	.01688	.01665 .01670	.01967	.02007	23
25	.01077	.01089	.01848	.01866	.01648	.01676	.01979	.02019	25
26	.01081	.01093	.01352	.01871	.01658	.01681	.01984	.02025	26
27	.01086	.01097	.01857 .01862	.01376 .01381	.01659	.01687	.01990	.02031	27
24 25 26 27 28 29	.01094	.01108	.01367	.01386	.01669	.01698	.02002	.02043	24 25 26 27 28 29
80	.01098	.01111	.01871	.01391	.01675	.01708	.02008	.09049	80
81	.01108	.01115	.01876	.01395	.01680	.01709	.02013	.02055	81
322	.01107	.01119	.01881	.01400	.01685	.01714	.02019	.02061	32 83
33 34	.01111	.01124	.01886 .01891	.01405 .01410	.01690	.01720	.02025	.02067	34
85	.01120	.01133	.01896	.01415	.01701	.01731	.02037	.02079	85 86
86 87	.01124	.01137	.01400	.01420	.01706	.01736	.02042	.02085	86
37 38	.01129 .01183	.01142 .01146	.01405	.01425 .01430	.01712	.01742	.02048	.02091	87
89	.01137	.01151	.01415	.01435	.01728	.01758	.02000	.02108	38
40	.01142	.01155	.01420	.01440	.01728	.01758	.02066	.02110	40
41	.01146	.01160	.01425	.01445	.01783	.01764	.02072	.02116	41
42	.01151	.01164	.01480	.01450	.01739	.01769	.02078	.02122	42
48 44	.01155 .01159	.01169 .01178	.01435	.01455 .01461	.01744 .01750	.01775 .01781	.02084	.02128	43 44
45	.01164	.01178	.01444	.01466	.01755	.01786	.02095	.02140	45
46	.01168	.01182	.01449	.01471	.01760	.01792	.02101	.02146	46
47 48	.01178	.01187	.01454	·01476 .01481	.01766	.01798	.02107	.02158	47
49	.01182	.01196	.01464	.01486	.01777	.01808 .01809	.02119	.02165	49
50	.01186	.01200	.01469	.01491	.01782	.01815	.02125	.02171	50
51	.01191	.01205	.01474	.01496	.01788	.01820	.02131	.02178	51
52 53	.01195	.01209	.01479	.01501	.01798	.01826	.02187	.02184	52 53
D3	.01200 .01204	.01214 .01219	.01484	.01508	.01799	.01832 .01837	.02148 .02149	.02190	54
55	.01209	.01228	.01494	.01517	.01810	.01843	.02145	.02203	55
56	.01218	.01228	.01499	.01522	.01815	.01849	.02161	.02209	55 56
DY	.01218 .01222	.01288	.01504	.01527 .01532	.01821	.01854	.02167	.02215	57 58
54 55 56 57 58 59 60	.01227	.01242	.01514	.01537	.01882	.01866	.02178	.02228	59.4
60	.01231	.01247	.01519	.01548	.01837	.01872	.02185	.02234	60

Vers. Ex. sec. Vers. Ver		,	1:	2.	1	3°	1	4.	1	5°	
1 0.02191 0.02447 0.02576 0.02637 0.02947 0.02946 0.03415 0.08584 3 0.02038 0.02583 0.02683 0.02865 0.02865 0.02865 0.02865 0.02865 0.02865 0.02866 0.02865 0.02866 0.00277 0.028616 0.02866 0.00287 0.02866 0.02866 0.00287 0.02866 0.02866 0.00287 0.02866 0.02866 0.00286 0.02866 0.00287 0.00286 0.02866 0.00286 0			, Vers.	Ex. sec.	Vers.	Ex. sec.	Vers.	Ex. sec.	Vers.	Ex. sec.	·
2 .02197 02247 02258 02588 02585 02851 02806 02802 02804 03004 03552 0256 02216 02266 02586 02586 02805 02809 03001 03438 03560 05688 02223 02272 02802 02872 03013 03106 03435 03568 02823 02223 02272 02802 02872 03013 03106 03435 03568 02802 02223 02272 02800 02873 03020 03114 03460 03568 02802 02802 02802 02802 03813 03106 03435 03568 02802 02802 02802 02802 03802 038114 03460 03564 03602 03812 03802 038	ľ										0
8 .02203 0.02255 0.02563 0.02663 0.02663 0.02664 0.03490 0.03453 0.02666 0.0266 0.0266	Į										1
. 402210 . 02256 . 02566 . 02568 . 02668 . 02999 . 03001 . 03488 . 03660 . 6 . 02223 . 02272 . 02802 . 02673 . 03013 . 03106 . 03453 . 03576 . 6 . 02224 . 02285 . 02279 . 02809 . 02879 . 03013 . 03114 . 03469 . 03584 . 7 . 02224 . 02285 . 02219 . 02802 . 02873 . 03013 . 03106 . 03453 . 03594 . 9 . 02240 . 02281 . 02822 . 02828 . 02829 . 02808 . 03024 . 03121 . 03469 . 03592 . 1 . 02246 . 02228 . 02229 . 02204 . 02289 . 02700 . 00041 . 03127 . 03488 . 03609 . 1 . 1 . 02246 . 02228 . 02231 . 02823 . 02710 . 00041 . 03137 . 03488 . 03609 . 1 . 1 . 02253 . 02204 . 02835 . 02711 . 02848 . 03123 . 03144 . 03491 . 03617 . 1 . 1 . 02258 . 02311 . 02849 . 02712 . 03045 . 03152 . 03489 . 03635 . 1 . 1 . 02253 . 02311 . 02849 . 02724 . 03055 . 03152 . 03489 . 03635 . 1 . 1 . 02227 . 02230 . 02855 . 02728 . 02728 . 03077 . 03175 . 03514 . 03849 . 03855 . 1 . 1 . 02277 . 02230 . 02855 . 02728 . 03077 . 03175 . 03521 . 03634 . 02871 . 02849 . 02835 . 02849 . 02835 . 02849 . 02835 . 02849 . 02835 . 02849 . 02835 . 02849 . 02835 . 02849 . 02835 . 02849 . 02835 . 02849 . 02835 . 02849 . 02835 . 02849 . 02835 . 02836 . 02838 . 02838 . 028		2 2									8
5	.1	4		02259							4
7 0.22284 0.2279 0.2806 0.2807 0.0809 0.0814 0.08408 0.08592 0.0816 0.2828 0.0827 0.08121 0.08468 0.08592 0.0816 0.0828 0.08024 0.08129 0.08476 0.08001 10 0.02246 0.2298 0.2029 0.2029 0.08004 0.08139 0.08476 0.08001 11 0.2228 0.2298 0.2029 0.08204 0.08034 0.08139 0.08476 0.08001 11 0.02289 0.2804 0.08285 0.2770 0.08048 0.08142 0.08491 0.08167 11 0.02289 0.2811 0.08482 0.08714 0.00055 0.08152 0.08498 0.08017 11 0.08285 0.28117 0.08498 0.08721 0.08068 0.08152 0.08498 0.08055 11 0.08287 0.28281 0.28271 0.28283 0.28055 0.2728 0.09070 0.08167 0.08167 0.08164 0.08632 11 0.08277 0.28390 0.20069 0.27251 0.09077 0.08167 0.08164 0.08632 11 0.08288 0.28336 0.20069 0.2748 0.09077 0.08167 0.08524 0.08528 0.2728 0.08077 0.08167 0.08529 0.0858 11 0.02208 0.2336 0.20069 0.2749 0.09004 0.08190 0.03527 0.08528 0.2726 0.0908 0.0918 0.08544 0.08528 0.2726 0.0908 0.0918 0.08544 0.08642 12 0.08208 0.2303 0.2006 0.2770 0.08113 0.08204 0.08528 0.0875 0.0809 0.08708 0.08198 0.08544 0.08654 0.0869 0.2749 0.08004 0.08198 0.08544 0.08654 0.0869 0.2749 0.08004 0.08305 0.08508 0.0869 0.2770 0.08113 0.08211 0.08560 0.08691 0.2770 0.08113 0.08211 0.08560 0.08691 0.2770 0.08113 0.08211 0.08560 0.08691 0.2770 0.08113 0.08211 0.08560 0.08691 0.2770 0.08128 0.08211 0.08211 0.08560 0.08691 0.02771 0.08113 0.08221 0.08560 0.08691 0.02771 0.08113 0.08221 0.08560 0.08691 0.02716 0.02704 0.08104 0.08225 0.08560 0.08691 0.02705 0.08104 0.08225 0.08560 0.08108 0.08705 0.08709 0.02704 0.08104 0.08225 0.08560 0.08108 0.08705 0.08709 0.08704 0.08227 0.08289 0.02716 0.02704 0.08104 0.08225 0.08560 0.08709 0.08704 0.08104 0.08225 0.08560 0.08709 0.08704 0.08104 0.08225 0.08560 0.08709 0.08704 0.08225 0.0806 0.08704 0.08225 0.0806 0.08704 0.08225 0.0806 0.08704 0.08225 0.0806 0.08704 0.08225 0.0806 0.08704 0.08225 0.0806 0.08704 0.08225 0.0806 0.08704 0.08225 0.0806 0.08704 0.08225 0.0806 0.08704 0.08225 0.0806 0.08704 0.08225 0.0806 0.08704 0.08225 0.08235 0.08325 0.08325 0.08325 0.08325 0.08325 0.08325 0.08325 0.08325 0.08325 0.08325 0.08325 0.08325 0.08325	ŀ	5	.02216	.02266	.02596	.02665	.03006	.03099	.03445	.03568	5
8 0.2224 0.2225 0.2261 0.2262 0.2363 0.9027 0.9121 0.9486 0.9592 1 0.2246 0.2296 0.2269 0.26700 0.9041 0.9132 0.9483 0.9600 1 0.0046 0.2246 0.2296 0.26829 0.2700 0.9041 0.9137 0.9483 0.9600 1 0.0041 0.0055 0.2265 0.20311 0.2685 0.2711 0.9042 0.9771 0.9048 0.9144 0.9491 0.9617 1 0.0055 0.2265 0.2317 0.2649 0.2721 0.9068 0.9152 0.9496 0.9625 1 0.0041 0.9051 0	1	6		.02272							6
9 0.2246 0.2296 0.2296 0.2609 0.8700 0.8041 0.8137 0.8488 0.9809 14 11 0.2252 0.2204 0.2655 0.2707 0.8048 0.8144 0.8491 0.9617 12 12 0.2258 0.2317 0.2649 0.2714 0.8065 0.8152 0.8498 0.9625 11 13 0.2258 0.2317 0.2649 0.2721 0.8068 0.8159 0.8506 0.8638 11 14 0.2271 0.2330 0.2662 0.2725 0.8077 0.8167 0.8514 0.8683 11 15 0.2277 0.2330 0.2662 0.2725 0.8077 0.8167 0.8514 0.8683 11 16 0.2283 0.2386 0.2669 0.2742 0.8064 0.8183 0.8529 0.9638 11 17 0.2239 0.2343 0.2675 0.2749 0.8007 0.8167 0.8521 0.8660 11 18 0.2235 0.2349 0.2652 0.2756 0.8096 0.8198 0.3544 0.8674 11 19 0.2302 0.2356 0.2699 0.2743 0.8004 0.8305 0.3654 0.8674 11 19 0.2302 0.2356 0.2699 0.2770 0.8113 0.8213 0.3550 0.3669 12 21 0.2814 0.2869 0.2703 0.2777 0.8113 0.8213 0.3560 0.3669 12 22 0.2306 0.2362 0.2696 0.2770 0.8113 0.8213 0.3560 0.3669 12 23 0.2306 0.2362 0.2696 0.2770 0.8113 0.8213 0.3560 0.3669 12 24 0.2813 0.2837 0.2828 0.2716 0.2719 0.3124 0.2828 0.3575 0.3708 22 23 0.2820 0.2362 0.2763 0.8729 0.8113 0.8321 0.3560 0.3669 12 24 0.2833 0.2385 0.2729 0.2729 0.8149 0.2321 0.3568 0.3716 22 25 0.2239 0.2395 0.2726 0.2736 0.8114 0.3284 0.3500 0.8734 22 26 0.2845 0.2402 0.2736 0.2813 0.8156 0.2359 0.3668 11 27 0.2845 0.2402 0.2736 0.2813 0.8156 0.2359 0.3668 0.3741 22 28 0.2323 0.2395 0.2769 0.2799 0.8143 0.3244 0.3550 0.8734 22 29 0.2364 0.2415 0.2749 0.2837 0.3814 0.3236 0.3658 0.3716 22 29 0.2364 0.2441 0.2777 0.2849 0.3837 0.3614 0.3590 0.3678 23 28 0.2345 0.2446 0.2748 0.2836 0.3367 0.3614 0.3749 22 29 0.2364 0.2441 0.2777 0.2866 0.2384 0.3136 0.3387 0.3614 0.3749 22 29 0.2364 0.2441 0.2777 0.2866 0.2384 0.3138 0.3386 0.3637 0.3614 0.3749 22 28 0.2368 0.2448 0.2738 0.2836 0.3200 0.3366 0.3653 0.3791 33 0.22370 0.2448 0.2768 0.2834 0.3318 0.3386 0.3677 0.3621 0.3788 22 0.2368 0.2448 0.2788 0.2894 0.3386 0.3377 0.3364 0.3363 0.3474 38 0.2447 0.2468 0.2484 0.2897 0.2896 0.3314 0.3321 0.3368 0.3671 0.3864 44 0.2449 0.2441 0.2561 0.2891 0.2896 0.3314 0.3321 0.3368 0.3697 0.3814 0.3899 0.3844 0.3899 0.3844 0.3899 0.3844 0.3899 0.3844 0.3899 0.3844 0.3899	١					.02679		.03114			7
10 0.2246 0.2296 0.2299 0.2700 0.3041 0.3137 0.3483 0.3600 1.0 11 0.2253 0.2304 0.2655 0.2707 0.3048 0.3144 0.3491 0.3617 1.1 12 0.2258 0.2311 0.3349 0.2711 0.3055 0.3152 0.3498 0.3625 1.1 13 0.2265 0.2317 0.349 0.2721 0.3068 0.3159 0.3506 0.3633 1.1 14 0.2271 0.2323 0.2355 0.2655 0.3728 0.3070 0.3167 0.3514 0.3653 1.1 15 0.2277 0.2330 0.3662 0.2728 0.3070 0.3167 0.3514 0.3650 1.1 16 0.2258 0.2336 0.2369 0.2663 0.2728 0.3070 0.3167 0.3514 0.3650 1.1 17 0.2299 0.2343 0.2355 0.2699 0.3743 0.3064 0.3183 0.3529 0.3658 1.1 18 0.2295 0.2349 0.2362 0.2736 0.3098 0.3198 0.3544 0.3652 0.3652 0.3659 0.2739 0.2749 0.3006 0.3198 0.3544 0.3660 1.1 19 0.2302 0.2355 0.2349 0.2668 0.2770 0.3113 0.3213 0.3560 0.3652 0.3683 1.1 19 0.2305 0.2302 0.2766 0.2709 0.2774 0.3120 0.3221 0.3560 0.3691 2.2 20 0.2308 0.2363 0.2709 0.2774 0.3120 0.3221 0.3567 0.3699 2.2 22 0.2320 0.2275 0.2709 0.2734 0.3124 0.3221 0.3567 0.3699 2.2 23 0.2327 0.2382 0.2716 0.2711 0.3124 0.3224 0.3580 0.3763 0.3716 2.2 24 0.2335 0.2335 0.2732 0.2799 0.3143 0.3244 0.3580 0.37716 2.2 25 0.2339 0.2335 0.2732 0.2799 0.3143 0.3244 0.3580 0.37716 2.2 27 0.2328 0.2415 0.2736 0.2831 0.3156 0.3259 0.3606 0.3741 2.2 28 0.2384 0.2415 0.2749 0.2837 0.3117 0.3275 0.3614 0.3749 2.2 29 0.2388 0.2415 0.2749 0.2834 0.3156 0.3259 0.3606 0.3741 2.2 29 0.2388 0.2441 0.2777 0.2864 0.3127 0.3313 0.3366 0.3673 0.3749 2.2 29 0.2388 0.2441 0.2777 0.2866 0.3200 0.3313 0.3660 0.3673 0.3749 2.2 29 0.2388 0.2441 0.2777 0.2866 0.3200 0.3313 0.3660 0.3673 0.3749 2.2 29 0.2388 0.2441 0.2777 0.2866 0.3200 0.3313 0.3660 0.3673 0.3749 2.2 29 0.2389 0.2385 0.2441 0.2777 0.2866 0.3200 0.3313 0.3660 0.3673 0.3749 2.2 20 0.2388 0.2441 0.2777 0.2866 0.3200 0.3313 0.3660 0.3673 0.3749 2.2 20 0.2388 0.2441 0.2777 0.2866 0.3200 0.3313 0.3660 0.3673 0.3844 0.2441 0.2441 0.2277 0.2866 0.3200 0.3313 0.3660 0.3673 0.3844 0.2441 0.2441 0.2277 0.2866 0.3200 0.3313 0.3366 0.3379 0.3844 0.3869 0.3444 0.2441 0.2777 0.3866 0.3300 0.3313 0.3366 0.3077 0.3884 4.4 0.2449 0.2441 0.2777 0.2866 0.3200 0.3313 0.3366 0	ł	8						08121	08176		9
12	l			.02298	.02629		.03041		.03483	.03609	10
13 .02285 .02317 .02649 .02721 .03068 .03159 .03506 .03638 11 14 .02277 .02330 .02855 .02738 .09070 .03175 .08521 .03650 .11 16 .022283 .02336 .02699 .02742 .09064 .03183 .03529 .03650 .11 17 .02239 .02343 .02675 .02749 .09091 .03190 .03552 .03666 .17 18 .02235 .02349 .02683 .02766 .02096 .03196 .03544 .03666 .17 19 .02302 .02356 .02689 .02763 .03106 .03205 .03560 .03688 .18 20 .02364 .02352 .02689 .02777 .03130 .08221 .03560 .03681 .19 21 .02314 .02332 .02680 .02776 .02777 .03130 .08221 .03560 .03691 .223 .	l						.08048				11
14	l										12
15	1			02323							14
16 .02288 .02366 .02669 .02749 .03064 .03182 .03529 .03668 11 17 .02289 .02348 .02675 .02749 .03001 .03196 .03537 .03668 .1 18 .02289 .02349 .02682 .02763 .03106 .03205 .03552 .03681 .03600 .03283 .02689 .02770 .03113 .03213 .03563 .03660 .03270 .03113 .03213 .03567 .03691 .2 21 .02314 .02289 .02770 .02777 .03120 .08221 .03567 .03691 .2 22 .02320 .02273 .02716 .02771 .03120 .08221 .03567 .03699 .2 23 .02323 .022716 .027791 .03134 .03224 .03506 .03741 .2 .03583 .03686 .03732 .2 .2 .03339 .03235 .027280 .02806 .03149 .03251	١			.02330		.02735		.03175			15
18	١	16	.02288	.02336	.02669	.02742	.03084	.03182	.03529		16
19	1			.02348							17
20	ı		09900								
22 .028300 .028776 .02779 .02784 .03127 .03282 .03575 .03706 .03127 .03288 .03716 .02799 .03142 .03236 .03583 .03716 .22 .02739 .02799 .03142 .03244 .03590 .03774 .2 .02739 .02739 .02806 .03142 .03251 .03588 .03732 .2 .02738 .02813 .03156 .03259 .09606 .03741 .2 .03251 .03588 .08732 .2 .03163 .03259 .09606 .08741 .2 .03641 .03742 .2 .03628 .03414 .02743 .02807 .03117 .03275 .03614 .03749 .2 .03634 .03147 .03259 .03614 .03778 .2 .03634 .03178 .03229 .03644 .03778 .2 .03842 .03185 .03290 .03637 .03774 .3 .03237 .03414 .02777 .02849 .03193 .03290 .03637 .037	ı		.02308								20
24 .02838 .02328 .02729 .02799 .03142 .03244 .03596 .03732 .225 .03839 .03295 .02739 .02806 .03149 .03251 .03598 .03732 .22 .22 .02352 .02402 .02736 .02813 .03156 .03259 .03606 .03741 .22 .02352 .02408 .02748 .02820 .03163 .03847 .03614 .03749 .22 .03644 .02415 .02749 .02820 .03163 .03827 .03614 .03778 .22 .03644 .02415 .02749 .028287 .03171 .03275 .08621 .03778 .22 .03624 .03183 .03828 .03629 .08765 .02778 .03834 .03183 .03828 .03629 .08774 .32 .03838 .02435 .02770 .02849 .03193 .03898 .03445 .02777 .02849 .03193 .03898 .03445 .02779 .02870 .03214 .03221 .03668 .03806 <td>١</td> <td></td> <td>.02314</td> <td>.02369</td> <td>.02702</td> <td>.02777</td> <td>.03120</td> <td></td> <td>.03567</td> <td></td> <td>21</td>	١		.02314	.02369	.02702	.02777	.03120		.03567		21
24 .02838 .02328 .02729 .02799 .03142 .03244 .03596 .03732 .225 .03839 .03295 .02739 .02806 .03149 .03251 .03598 .03732 .22 .22 .02352 .02402 .02736 .02813 .03156 .03259 .03606 .03741 .22 .02352 .02408 .02748 .02820 .03163 .03847 .03614 .03749 .22 .03644 .02415 .02749 .02820 .03163 .03827 .03614 .03778 .22 .03644 .02415 .02749 .028287 .03171 .03275 .08621 .03778 .22 .03624 .03183 .03828 .03629 .08765 .02778 .03834 .03183 .03828 .03629 .08774 .32 .03838 .02435 .02770 .02849 .03193 .03898 .03445 .02777 .02849 .03193 .03898 .03445 .02779 .02870 .03214 .03221 .03668 .03806 <td>1</td> <td></td> <td>.02820</td> <td>.02375</td> <td>.02709</td> <td>.02784</td> <td>.03127</td> <td>.03228</td> <td>.03575</td> <td>.03708</td> <td>22</td>	1		.02820	.02375	.02709	.02784	.03127	.03228	.03575	.03708	22
25	1		.02827	.02882	.02716			.03236		.03716	28
28	١		02889	02395	02720			03244		08732	25
27 02352 02408 02743 02890 03163 03297 03614 03749 28 28 02358 02415 02749 02897 03171 03275 03621 03758 2 29 02364 02421 02756 02834 03178 03283 03629 03766 2 30 02370 02435 02763 02842 03185 03290 03637 03774 3 31 02377 02435 02770 02849 03193 03298 03645 03773 3 32 02388 02441 02777 02876 03200 03306 03660 03791 3 33 023896 02445 02780 02877 03274 03231 03660 03791 3 35 02408 02461 02797 02878 03222 03337 0364 03816 3 36 02408 02461 02797 <	١										26
29 0 .02364 .02421 .02766 .02884 .03178 .03283 .08629 .03764 38 30 0 .02370 .02428 .02763 .02842 .03185 .03290 .06377 .08783 38 31 0 .023777 .02849 .03193 .08298 .08455 .03791 38 32 0 .02388 .02441 .02777 .02866 .03200 .03306 .08653 .03791 33 34 0 .02386 .02448 .02788 .02866 .03207 .03314 .03301 .03668 .03806 .38906 .38908 .03446 .02787 .02878 .02428 .03806 .38908 .38 .03806 .03406 .03816 .03806 .38 .03406 .02468 .02804 .02885 .03229 .03376 .03816 .03806 .38 .03421 .02441 .02811 .02809 .03244 .03323 .03668 .03668 .03816 .03896 .03424 .03823	Т	27		.02408	.02748	.02820	.03163			.03749	27
30	Т	28		.02415	.02749	.02827	.08171	.03275	.03621	.03758	28
32 .02388 .02441 .02777 .02856 .03200 .03306 .03633 .03791 33 33 .02389 .02448 .02783 .02863 .03207 .03313 .03660 .03791 33 34 .02396 .02454 .02790 .02870 .03214 .03231 .03668 .03806 .03791 33 35 .02408 .02461 .02797 .02878 .03222 .03329 .03676 .03816 .03816 .03829 .03345 .03692 .03838 .03421 .03681 .03629 .03345 .03692 .03838 .03421 .03681 .03692 .03838 .03421 .03681 .03692 .03838 .03942 .03835 .03699 .03838 .03421 .03681 .03692 .03838 .03692 .03838 .03692 .03838 .03692 .03838 .03692 .03838 .03692 .03838 .03692 .03838 .03692 .03838 .03692 .03838 .0	١			.02421	.02768			.03290			80
33 .02389 .02448 .02788 .02637 .03317 .03668 .03708 .03606 .03709 .03806 .03454 .02790 .03870 .03212 .03329 .03668 .03806 3 35 .02408 .02461 .02797 .02878 .03222 .03329 .03676 .03816 3 36 .02408 .02441 .02811 .02892 .03236 .03345 .03692 .03837 .03684 .03828 .03836 .03699 .03833 3 38 .02421 .02481 .02894 .02809 .03244 .03353 .03699 .03843 3 40 .02434 .02494 .02831 .02914 .03258 .03368 .03715 .03850 3 41 .02440 .02501 .02836 .02921 .03266 .03876 .03723 .03854 4 41 .02447 .02508 .02845 .023928 .03273 .03734 .03731 <t< td=""><td>1</td><td></td><td></td><td></td><td></td><td></td><td></td><td>.03298</td><td></td><td>.03783</td><td>31</td></t<>	1							.03298		.03783	31
34 .02396 .02454 .02790 .02870 .03214 .03281 .03668 .03816 3 35 .02402 .02461 .02797 .03878 .03292 .03337 .03676 .03816 3 36 .02408 .02404 .02815 .03229 .03337 .03684 .03825 3 37 .02415 .02811 .02812 .03286 .03844 .03633 .03699 .03242 .03833 .03699 .03424 .03833 .03699 .03424 .03333 .03699 .03424 .03833 .03690 .03715 .03686 .03707 .03850 3 40 .02434 .02494 .02831 .02914 .03833 .03866 .03775 .03586 4 41 .02440 .02831 .02921 .03866 .03776 .03723 .03867 4 43 .02447 .02508 .02836 .02928 .03876 .03723 .03867 4 <t< td=""><td>1</td><td></td><td>.02388</td><td></td><td></td><td></td><td>.03200</td><td>.03306</td><td></td><td>09791</td><td>32</td></t<>	1		.02388				.03200	.03306		09791	32
35 .02402 .02461 .02707 .02878 .03222 .03329 .03676 .03816 .03825 38 36 .02408 .02804 .02885 .03229 .03326 .03345 .03692 .03838 38 37 .02421 .02421 .02811 .02892 .03244 .03333 .06992 .03833 3 39 .02427 .02488 .02894 .028907 .03251 .03360 .03777 .03551 .03660 .03775 .03550 3 40 .02434 .02494 .02831 .02914 .08258 .03368 .03715 .03658 4 41 .02440 .02508 .02834 .02921 .08268 .03876 .03723 .03864 .03731 .03675 4 43 .02447 .02508 .02832 .02828 .032873 .03344 .03731 .03875 4 43 .02453 .02515 .02832 .02328 .03281 <td>ı</td> <td></td> <td></td> <td></td> <td>02790</td> <td>.02870</td> <td></td> <td>03321</td> <td>.03668</td> <td>.03808</td> <td>34</td>	ı				02790	.02870		03321	.03668	.03808	34
37 .02415 .02474 .02811 .02892 .03286 .0345 .03699 .03834 38 38 .02421 .02481 .02818 .02899 .03244 .03699 .03843 38 39 .02427 .02488 .02824 .02907 .03251 .03360 .08707 .03850 33 40 .02434 .02494 .02831 .02914 .03258 .03368 .03715 .03858 44 41 .02440 .02501 .02838 .02921 .03866 .08376 .03723 .03867 44 43 .02447 .02508 .02845 .02928 .03273 .03344 .03731 .03875 44 43 .02453 .02525 .02836 .03281 .03293 .03739 .03844 44 .02459 .02521 .02859 .02936 .03295 .03408 .03771 .03802 4 45 .02466 .02528 .02866	١		.02402		.02797	.02878	.03222	.03329		.03816	35
38 .08421 .02481 .02818 .02899 .03244 .03258 .08699 .03842 .38 39 .02427 .02488 .02824 .02907 .03251 .03360 .03707 .03850 .38 40 .02484 .02494 .02831 .02914 .03288 .03288 .03688 .03715 .03858 44 41 .02440 .02801 .02838 .02921 .08266 .02376 .03723 .03867 4 42 .02447 .02508 .02828 .03281 .03394 .03731 .03873 .03884 43731 .03873 .03884 44 .03453 .02515 .02852 .02938 .03281 .03894 .03731 .03874 44 .02453 .02511 .02859 .02943 .03285 .03400 .03747 .03894 44 .02466 .02352 .02866 .02350 .032935 .03406 .03747 .03894 47 .02472 .02535 .02896	١	36					.03229	.03337		.03825	86
39 0.2427 .02488 .02824 .02907 .03251 .03360 .03707 .03850 3 40 .02484 .02494 .02831 .02914 .03258 .03368 .03715 .03858 4 41 .02440 .02801 .02838 .02921 .08266 .03876 .03731 .03876 .03867 4 42 .02447 .02308 .02845 .02928 .03273 .03394 .03731 .03875 .03884 44 43 .02453 .02515 .02836 .02896 .03296 .03400 .03731 .03854 44 44 .02459 .02525 .02896 .03295 .03400 .03747 .03802 4 45 .02466 .02525 .02896 .03295 .03408 .03774 .03802 4 47 .02479 .02535 .02896 .0303 .03416 .03732 .03964 .03777 .03918 4 <t< td=""><td>1</td><td></td><td></td><td></td><td></td><td></td><td></td><td>.03345</td><td></td><td>.08888</td><td></td></t<>	1							.03345		.08888	
40	1							03360			39
42	١						.03258				40
43 02453 02515 02852 02838 03881 08381 08393 03739 03884 44 44 02459 02521 02859 02943 03288 03400 03774 03832 4 45 02466 02528 02866 02360 03295 03408 03774 03801 4 46 02472 02535 02873 02956 03303 03416 03770 03991 4 47 02479 024242 028990 02966 03310 03416 03770 03918 4 48 02485 02548 02897 02972 03818 04832 03778 03927 4 49 02492 02553 02894 02990 02936 03333 03447 03796 03937 4 50 02498 02553 02894 02990 02933 03439 08786 03937 4 51 02504	1							.08376			41
44 02459 02521 02859 02943 03288 08400 03774 038901 4 45 02466 02528 02868 02850 03293 03408 03575 03901 4 46 02472 02535 02873 02958 0303 03416 03762 03900 4 47 02479 02542 02890 02965 03310 03434 03770 03918 4 48 02485 02548 02897 02972 03318 03432 08778 03927 4 49 02492 02555 0294 02980 -03325 03439 08786 03935 4 50 02498 02569 02900 02987 03333 03447 03794 08944 5 51 02504 02569 02900 02987 03333 03447 03794 08944 5 52 02511 02569 02907 <t< td=""><td>1</td><td></td><td></td><td></td><td></td><td>.02928</td><td>.03278</td><td>.03384</td><td>.03781</td><td>.03875</td><td>42</td></t<>	1					.02928	.03278	.03384	.03781	.03875	42
45	1								00747		44
46					.02866		.03295				45
48	1	46	.02472	.02535	.02878	.02958	.03303	.03416	.03762	.03909	46
49 0.2492 0.2555 0.2894 0.2980 - 0.3325 0.3439 0.9786 0.9385 4 50 0.2498 0.2563 0.02907 0.2997 0.3485 0.3485 0.8902 0.8952 5 51 0.2504 0.2269 0.2907 0.2994 0.8840 0.3485 0.8902 0.8952 5 52 0.2511 0.2576 0.2914 0.3002 0.8347 0.3463 0.9810 0.9891 0.5901 0.8961 0.8969 5 0.810 0.9891 0.8969 5 0.8471 0.9886 0.3978 5 0.8471 0.9886 0.3978 5 0.8479 0.8884 0.3878 0.8684 0.3878 0.8684 0.3895 5 0.8684 0.3895 0.8684 0.3895 5 0.8684 0.3895 5 0.8684 0.3895 5 0.8684 0.3895 5 0.8684 0.3895 5 0.8684 0.3895 5 0.8684 0.3895 5			.02479		.02380	.02965	.03310	.03424	.03770	.03918	47
50 .02498 .02562 .02900 .02987 .03333 .03447 .03794 .03944 b 51 .02504 .02569 .02907 .02994 .03840 .03455 .03802 .03952 5 52 .02511 .02576 .02914 .03002 .03347 .03463 .03810 .03910 .05961 5 53 .02517 .02582 .02921 .03009 .03352 .08471 .03818 .03969 5 54 .02594 .02596 .02932 .03017 .03382 .08479 .03836 .03978 5 55 .02500 .02596 .02935 .03024 .03870 .04477 .03842 .03897 .5 56 .02537 .02603 .02942 .03032 .03377 .03495 .03842 .03995 .5 57 .02543 .02617 .02946 .03902 .03503 .03835 .03803 .03850 .04004 5	1			.02548		02972	.03318		.08778	09987	48 49
52 02511 02576 02914 03002 03847 03468 03810 03996 5 53 02517 02582 02921 03009 03835 08471 03818 03909 5 54 02594 02589 02928 03017 03362 03479 03826 03978 5 55 02530 02596 02928 03017 03802 03479 03826 03978 5 56 02537 02608 029242 03032 03377 03495 08642 03995 5 57 02548 02610 029349 03039 03855 03503 03850 04004 5 58 02550 02617 02956 03046 03892 03512 03512 03618 04018 5							.03333				50
53 .02517 .02582 .02921 .03009 .03355 .08471 .08918 .03969 .5 54 .02584 .02589 .02928 .03017 .03862 .03479 .08266 .03978 5 55 .02530 .02596 .02935 .03024 .03370 .03487 .03864 .03967 5 56 .02537 .02608 .02949 .03032 .08377 .08495 .08422 .03995 5 57 .02543 .02610 .02949 .03039 .03385 .03503 .08500 .04004 5 58 .02550 .02617 .02965 .03046 .03392 .03512 .03503 .04013 5											51
54 .02594 .02598 .02928 .03017 .03362 .08479 .03826 .03978 5 55 .02530 .02596 .03835 .03024 .03870 .03487 .03824 .03987 5 56 .02537 .02603 .02942 .03032 .08377 .03495 .03842 .03995 5 57 .02543 .02610 .02949 .03039 .03885 .03503 .03850 .04004 5 58 .02550 .02617 .02956 .03046 .03922 .03512 .03888 .04013 \$	1										52 53
55 .02530 .02596 .02935 .03024 .03370 .03487 .03834 .03987 5 56 .02537 .02603 .02942 .03032 .08377 .03495 .08492 .03995 5 57 .02543 .02610 .02949 .03039 .03385 .03503 .03850 .04004 5 58 .02560 .02617 .02956 .03046 .03392 .03512 .08588 .04013 15	1										54
58 .02550 .02617 .02956 .03046 .03392 .03512 .03858 .04013 5		55	.02530	.02596	.02935	03024	.03370	.03487	.03834	.03987	55
58 .02550 .02617 .02956 .03046 .03392 .03512 .03858 .04013 5	1	56				.03032				.03995	56
		57				.03039	.03385				57
							03400	.03520	88880		59
		~		.02630	.02970	.03061		.03528	.03874	.04030	60

TABLE IV.—NATURAL VERSED SINES AND EXTERNAL SECANTS.

,	16*		16• 17•		. 1	8•	1		
	Vers.	Ex. sec.	′						
0	.08874	.04080	.04370	.04569	.04894	.05146	.05448	.05762	0
1	.03889	.04039	.04378	.04578	.04903	.05156	.05458	.05778	1
2	.03890	.04047	.04387	.04588	.04912	.05166	.05467	.05788	2 8
4	.03906	.04065	.04404	.04606	.04930	.05186	.05486	.05794	3
5	.03914	.04073	.04412	.04616	.04939	.05196	.05496	.05815	4 5 6 7
6	.03922	.04082	.04421	.04625	.04948	.05206	.05505	05828	6
7	.03930	.04091	.04429	.04635	.04957	.05216	.05515	.05836	7
8	.03938	.04100 .04108	.04438	.04644	.04967	.05226	.05524	.05847	8
10	.08954	.04117	.04455	.04663	.04985	.05246	.05584	.05858	10
11	.08968	.04126	.04464	.04672	.04994	.05256	.05558	.05879	11
12 13	.08971	.04185	.04472	.04682	.05008	.05266	.05562	.05890	12
14	.03987	.04152	.04489	.04700	.05021	.05286	.05572	.05911	14
15	.03995	.04161	.04498	.04710	.05030	05297	.05591	.05922	15
16	.04008	.04170	.04507	.04719	.05039	.05307	.05601	.05933	16
17	.04011	.04179	.04515	.04729	.05048	.05317	.05610	.05944	17
18 19	.04019	.04188	.04524	.04788 .04748	.05057	.05327	.05620	.05955	18
20	.04086	.04206	.04541	.04757	.05076	.05347	.05639	.05976	19 20
21	.04044	.04214	.04550	.04767	.05085	.05857	.05649	.05987	21
22	.04052	.04228	.04559	.04776	.05094	.05367	.05658	.05998	22
23	04060	.04232	.04567	.04786	.05103	.05878	.05668	.06009	28
24	.04069	.04241	.04576	.04795	.05112	.05388	.05678	.06020	24 25
25 26 27	.04085	.04259	.04593	.04815	.05131	.05408	.05697	.06041	26
27	.04098	.04268	.04602	.04824	.05140	.05418	.05707	.06052	27
28	.04102	.04277	.04611	.04834	.05149	.05429	.05716	.06068	28
29 30	.04110 .04118	.04286	.04620	.04843	.05158	.05439	.05726	.06074	29 30
81	.04126	.04804	.04637	.04863	.05177	.05460	.05746	.06096	81
82	.04185	.04318	.04646	.04872	.05186	.05470	.05755	.06107	82
33 34	.04148 .04151	.04322	.04655	.04882	.05195	.05480	.05765	.06118	83 84
85	.04159	.04340	.04672	.04901	.05214	.05501	.05785	.06140	85
86 87	.04168	.04349	.04681	.04911	.05223	.05511	.05794	.06151	86
87	.04176	. 04358	.04690	.04920	.05232	.05521	.05804	.06162	87
38	.04184	.04367	.04699	.04930	.05242	.05532	.05814	.06173	88
39 40	.04193 .04201	.04376	.04707	.04940	.05251	.05542 .05552	.05824	.06184 .06195	89 40
41	.04209	.04894	.04725	.04959	.05270	.05563	.05843	.06206	41
42 43	.04218	.04403	.04734	.04969	.05279	.05578	.05853	.06217	42 43
43 44	.04284	.04418	.04748	.04979	.05298	.05584 .05594	.05863	.06239	44
45	.04248	.04431	.04760	.04998	.05807	05604	.05882	.06250	45
46	.04251	.04440	.04769	.05008	.05316	.05615	.05892	.06261	46
47	.04260	.04449	.04778	.05018	.05326	.05625	.05902	.06272	47
48	.04268	.04458	.04787	.05028	.05385	.05686	.05912	.06283	48
49 50	.04276	.04468 .04477	.04796 .04805	.05038 .05047	.05344 .05354	.05646	.05922 .05932	.06295 .06306	49 50
51	.04293	.04486	.04814	.05057	.05363	.05667	.05942	.06817	51
52 58	.04302	.04495	.04823	.05067	.05373	.05678	.05951	.06328	52 58
54	.04319	.04504	.04841	.05087	.05391	.05699	.05971	.06350	54
55	.04827	.04528	.04850	.05097	.05401	.05709	.05981	.06862	55
56	.04836	.04532	.04858	.05107	.05410	.05720	.05991	.06378	56 57
57	.04844	.04541	.04867	.05116	.05420	.05780	.06001	.06384	57
58 59	.04858 .04861	.04551	.04876	.05126 .05136	.05429	.05741 .05751	.06011	.06407	58 59 60
60	.04870	.04569	.04894	.05146	.05448	.05762	.06031	.06418	ÃŎ

	2	0°	2	1•	2:	2°	2:	B°	,
	Vers.	Ex. sec.	Vers.	Ex. sec.	Vers.	Ex. sec.	Vers.	Ex. sec.	
0	.06031	.06418	.06642	.07115	.07282	.07858	.07950	.08636	0
1 2	.06041 .06051	.06429 .06440	.06652	.07126 .07138	.07293	.07866	.07961	.08649	1 2
8	.06061	.06452	.06673	.07150	.07814	.07892	.07984	.08676	2 8
4 5	.06071	.06468	.06684	.07162	.07325	.07904	.07995	.08690	5
6	.06091	.06486	.06705	.07186	.07347	.07930	.08018	.08717	6
7	.06101	.06497	.06715	.07199	.07358	.07948	.08029	.08730	7
8	.06111	.06508	.06726 .06736	.07211	.07369	.07955	.08041	.08744	8
10	.06131	.06581	.06747	.07235	.07891	.07981	.08064	.08771	10
11	.06141	.06542	.06757	.07247	.07402	.07994	.08075	.08784	11
12 18	.06151 .06161	.06564	.06768	.07259 .07271	.07418	.08006	.08086	.08798	12 13
14	.06171	.06577	.06789	.07283	.07485	.08032	.08109	.08825	14
15	.06181	.06588	.06799	.07295	.07446	.08045	.08121	.08839	15
16 17	.06191 .06201	.06600 .06611	.06810	.07807 .07820	.07457	.08058	.08132	.08866	16 17
18	.06211	.06622	.06831	.07832	.07479	.08084	.08155	.08880	18
19 20	.06221	.06634	.06841	.07844	.07490 .07501	.08097	.08167	.08993	19 20
21	.06241	.06657	.06863	.07868	.07512	.08122	.08190	.08921	21
22 23	.06252	.06668	.06873	.07380	.07523 .07534	.08135	.08201	.08934	22
24	.06272	.06091	.06894	.07405	.07545	.08161	.08225	.08962	24
25 26	.06282	.06703	.06905	.07417	.07556	.08174	.08236	.08975	25 26
27	.06302	.06715	.06916	.07429	.07568 .07579	.08187	.08259	.09003	27
28	.06312	.06738	.06937	.07454	.07590	.08213	.08271	.09017	28
29 80	.06323	.06749	.06948 .06958	.07466	.07601 .07612	.08226	.08282	.09030	29 30
81	.06343	.06778	.06969	.07491	.07623	.08252	.08306	.09058	81
82 83	.06353	.06784	.06980	.07503 .0751 6	.07634	.08265	.08317	.09072	32 33
84	.06374	.06807	.07001	.07528	.07657	.08291	.08340	.09099	34
85	.06384	.06819	.07012	.07540	.07668	.08305	.08352	.09118	85 86
86 87	.06394	.06831	.07022	.07558 .07565	.07679	.08318	.08364	.09127	87
88	.06415	.06854	.07044	.07578	.07701	.08344	.08387	.09155	88
89 40	.06425 .06435	.06866 .06878	.07055 .07065	.07590 .07602	.07713	.08357	.08399	.09169	89 40
41	.06445	.06889	.07076	.07615	.07735	.08383	.08422	.09197	41
42 43	.06456 .06466	.06901	.07087	.07627	.07746	.08397	.08434	.09211	42 43
44	.06476	.06925	.07108	.07652	.07769	.08423	.08457	.09238	44
45	.06486	.06936	.07119	.07665	.07780	.08436	.08469	.09252	45
46 47	.06497	.06948	.07130	.07677	.07791	.08449	.08481	.09266	46 47
48	.06517	.06972	.07151	.07702	.07814	.08476	.08504	.09294	48
49 50	.06528	.06984	.07162	.07715	.07825	.08489	.08516	.09308	49 50
51	.06548	.07007	.07184	.07740	.07848	.08516	.08539	.09337	51
52 58	.06559	.07019	.07195	.07752	.07859	.08529	.08551	.09351	52 53
54	.06580	.07043	.07216	.07778	.07881	.08556	.08575	.09879	54
55	.06590	.07055	.07227	.07790	.07893	.08569	.08586	.09393	55 56
56	.06611	.07087	.07238	.07803 .07816	.07904	.08596	.08610	.09407	57
	.06621	.07091	.07260	.07828	.079:27	.08609	.08622	.09435	58
	.06632 .06642	.07103	.07271	.07841	.07938	.08623	.08684	.09449	59 60
	.00042	.07115	1 .07262	.07853	.07950	.08686	.08045	.09404	100

0 . 1 . 2 . 3 . 4 . 5 .	Vers. 08645 08657 08669 98681 08693 08705 08717	.09464 .09478 .09492 .09506	Vers. .09369 .09382	Ex. sec.	Vers.	Ex. sec.	Vers.	Ex. sec
1 2 . 3 . 4 . 5 .	09657 09669 98681 08693 08705	.09478 .09492 .09506	.09382	10338			7015	2014. BOC.
2 . 3 . 4 . 5 .	08669 98681 08698 08705	.09492 .09506			.10121	.11260	.10899	.12233
3 . 4 . 5 .	.08681 .08693 .08705	.09506		.10353	.10133	.11276	.10918	.12249
5 . 6 .	08693 08705		.09394	.10368	.10146	.11292	.10926	.12266
5 .	.08705	.09520	.09406 .09418	.10383	.10159	.11308 .11323	.10939 .10952	.12283
		.09535	.09431	.10418	.10184	.11839	.10965	.12316
P 1		.09549	.09443	.10428	.10197	.11855	.10979	.12333
7 .	08728	.09563	.09455	.10443	.10210	.11371	.10992	.12349
	.08740 .08752	.09577	.09468	.10458 .10478	.10223	.11887	.11005	.12366 .12383
	08764	.09606	.09493	.10488	.10248	.11419	.11032	.12400
	.08776	.09620	.09505	.10508	.10261	.11485	.11045	.12416
	.08788 .08800	.09635	.09517	.10518 .10533	.10274	.11451 .11467	.11058	.12433 .12450
	08812	.09663	.09542	.10549	.10300	.11488	.11085	.12467
15	08824	.09678	.09554	.10564	.10313	.11499	.11098	.12484
	.08836	.09692	.09567	.10579	.10326	.11515	.11112	.12501
	.08848	.09707	.09579	.10594	.10338	.11581	.11125	.12518 .12534
	.08860 .08872	.09721	.09592	.10609 .10625	.10351	.11547 .11568	.11188 .11152	.12551
	08884	.09750	.09617	.10640	.10377	.11579	.11165	.12568
	08896	.09764	.09629	.10655	.10390	.11595	.11178	.12585
22 .	.08908	.09779	.09642	.10670	.10403	.11611	.11192	.12602
	.08920 .08932	.09793	.09654	.10686	.10416	.11627 .11643	.11205	.12619 .12636
	.08944	.09822	.09679	.10701 .10716	.10429	.11659	.11232	.12653
26	.08956	.09837	.09691	.10781	.10455	.11675	.11245	.12670
27 .	.08968	.09851	.09704	.10747	.10468	.11691	.11259	.12687
28 .	.08980	.09866	.09716	.10762	.10481	.11708	.11272	12704
29 . 30 .	.08992 .09004	.09880 .09895	.09729	.10777	.10494 .10507	.11724 .11740	.11285 .11299	.12721 .12738
81 .	.09016	.09909	.09754	.10808	.10520	.11756	.11812	.12755
	.09028	.09924	.09767	.10824	.10533	.11772	.11326	.12772
	.09040 .09052	.09939	.09779	.10839 .10854	.10546	.11789 .11805	.11339 .11353	.12789 .12807
85	.09064	.09968	.09804	.10870	10572	.11821	11366	.12824
36 .	.09076	.09982	.09817	.10885	.10585	.11838	.11380	.12841
37 .	.09089	.09997	.09829	.10901	.10598	.11854	.11893	.12858
38	.09101 .09118	.10012 .10026	.09842	.10916	.10611	.11870 .11886	.11407 .11420	.12875 .12892
	.09125	.10041	.09867	.10947	.10024	.11903	.11434	.12910
	.09137	.10055	.09880	.10963	.10650	.11919	.11447	.12927
	.09149	.10071	.09892	.10978	.10663	.11936	.11461	.12944
	.09161 .09174	.10085	.09905	.10994 .11009	.10676 .10689	.11952 .11968	.11474	.12961 .12979
45 .	.09186	.10115	.09930	.11005	.10702	.11985	.11501	.12996
46 .	09198	.10180	.09943	.11041	.10715	.12001	.11515	.13013
47	09210	.10144	.09955	.11056	.10728	.12018	.11528	.13031
48	.09222 .09234	.10159 .10174	.09968	.11072 .11087	.10741 .10755	.12034 .12051	.11542 .11555	.13048
	.09247	.10174	.09993	.11103	.10768	.12031	.11569	.13065
51 .	.09259	.10204	.10006	.11119	.10781	.12084	.11583	.13100
52 .	.09271 .09283	.10218	.10019	.11134	.10794	.12100	.11596	.13117
54	.09296	.10233	.10032	.11150 .11166	.10807	.12117 .12183	.11610	.13135 .13152
55	.09308	.10263	.10057	.11181	.10833	.12150	.11637	.13170
56 .	.09320	.10278	.10070	.11197	.10847	.12166	.11651	.13187
57	.09332	.10293	.10082	.11213	.10960	.12188	.11664	.13205
58	.09845 .09857	.10308 .10323	.10095 .10108	.11229	.10873	.12199 .12216	.11678 .11692	.13222
60	09869	10338	.10121	.11260	.10899	.12233	.11705	13257

2	8°	2	9°	3	0°	3	1•	
Vers.	Ex. sec.	Vers.	Ex. sec.	Vers.	Ex. sec.	Vers.	Ex. sec.	
.11705	.13257	.12538 .12552	.14335	.13397	.15470	.14283	.16663 .16684	0
.11788	.13292 .13310	.12566 .12580	.14372	.13427	.15509 .15528	.14313	.16704	2
.11746 .11760	.13327	.12595	.14409	.13456	.15548	.14343	.16725	2 8 4 5
.11774	.13345	.12609	.14428	.18470	.15567	.14358	.16766	5
.11787 .11801	.13362 .13380	.12623 .12637	.14446 .14465	.13485 .13499	.15587 .15606	.14373	.16786 .16806	6 7 8
.11815	.13398	.12651	.14483	.13514	.15626	.14403	.16827	
.11828 .11842	.13415 .13433	.12665 .12679	.14502 .14521	.13529	.15645 .15665	.14418 .14433	.16848 .16868	9 10
.11856 .11870	.13451 .13468	.12694 .12708	.14589 .14558	.18558 .18573	.15684 .15704	.14449	.16889 .16909	11 12
.11883	.13486	.12722	.14576	.13587	.15724	.14479	.16930	18
.11897	.13504	.12736	.14595	.13602	.15748	.14494	.16950	14
.11911 .11925	.13521 .13539	.12750 .12765	.14614 .14632	.13616 .13631	.15763	.14509	.16971	15 16
.11938	.13557	.12779	.14651	.13646	.15802	.14539	.17012	17
.11952 .11966	.18575 .18593	.12793 .12807	.14670 .14689	.13660 .13675	.15822 .15841	.14554	.17033 .17C54	18 19
.11980	.13610	.12822	.14707	.18690	.15861	.14584	.17075	20
.11994 .12007	.13628 .13646	.12836 .12850	.14726 .14745	.13705	.15881 .15901	.14599	.17095	21 22
.12007	.13664	.12864	.14764	.13734	.15920	.14630	.17110	23
.12035	.13682	.12879	.14782	.13749	.15940	.14645	.17158	24
.12049 .12063	.13700 .13718	.12893	.14801 .14820	.13763 .13778	.15960 .15980	.14660 .14675	.17178	25 26
.12077	.13735	.12921	1.14839	.13793	.16000	.14690	.17220	27
.12091	.1375 3 .13771	.12936 .12950	.14858 .14877	.13808 .13822	.16019	.14706	.17241	28 29
.12104 .12118	.18789	.12964	.14896	.13837	.16059	.14721 .14736	.17262	80
.12132 .12146	.18807 .18825	.12979	.14914 .14933	.13852 .13867	.16079 .16099	.14751	.17304	31 32
.12160	.13843	.13007	.14952	.13881	.16119	.14782	.17846	83
.12174 .12188	.13861	.13022	.14971 .14990	.13896	.16189 .16159	.14797	.17367 .17388	84 85
.12202	.13897	.13050	.15009	.13926	.16179	.14827	.17409	86
.12216	.13916	.13065	.15028	.13941	.16199	.14843	.17430	37
.12230 .12244	.13934	.13079 .13094	.15047 .15066	.13955	.16219 .16239	.14858	.17451	88 39
.12257	.13970	.13108	.15085	.13985	.16259	.14888	.17493	40
.12271 .12285	.13988 .14006	.13122 .13137	.15105 .15124	.14000 .14015	.16279	.14904	.17514 .17585	41 42
.12299	.14024	.13151	.15124	,14030	.16819	.14934	.17556	43
.12313	.14042	.13166	.15162	.14044	.16339	.14949	.17577	44
.12327 .12341	.14061	.13180 .13195	.15181 .15200	.14059	.16359 .16380	.14965	.17598 .17620	45 46
. 12355	.14097	.13209	.15219	.14089	.16400	.14995	.17641	47
.12369 .12383	.14115	.13223	.15239 .15258	.14104	.16420 .16440	.15011 .15026	.17662	48 49
.12397	.14152	.13252	.15277	.14184	.16460	.15041	.17704	50
.12411 .12425	.14170 .14188	.13267 .13281	.15296 .15315	.14149	.16481 .16501	.15057	.17726 .17747	51 52
.12439	.14207	.13296	.15335	.14179	.16521	.15087	.17768	53
.12454	.14225	.13310	.15854	.14194	.16541	.15103	.17790	54
.12468 .12482	.14243 .14262	.18325	.15373 .15393	.14208	.16562 .16582	.15118 .15184	.17811 .17832	55 56
.12496	.14280	.13354	.15412	.14238	.16602	.15149	.17854	57
.12510 .12524	.14299 .14317	.13368	.15431 .15451	.14258	.16623 .16643	.15164 .15180	.17875 .17896	58 59
.12538	.14335	.13397	.15470	14283	.16663	.15195	17918	60

TABLE IV .- NATURAL VERSED SINES AND EXTERNAL SEC.

	8	2•	3	3°	8	4°	8	5°
'	Vers.	Ex. sec.	Vers.	Ex. sec.	Vers.	Éx. sec.	Vers.	Ex. sec.
0 1 2 8 4 5 6 7 8 9	.15195 .15211 .15226 .15241 .15257 .15272 .15288 .15803 .15319 .15834 .15850	.17918 .17989 .17961 .17982 .18004 .18025 .18047 .18048 .18090 .18111 .18133	.161:33 .16149 .16165 .16181 .16196 .16212 .16228 .16244 .16260 .16276 .16292	.19236 .19259 .19281 .19304 .19327 .19349 .19372 .19394 .19417 .19440 .19468	.17096 .17118 .17129 .17145 .17161 .17178 .17194 .17210 .17227 .17243 .17259	.20622 .20645 .20669 .20698 .20717 .20740 .20764 .20768 .20812 .20836	.18085 .18101 .18118 .18135 .18152 .18168 .18185 .18202 .18218 .18235 .18252	.92077 .92102 .92127 .92152 .92177 .92902 .92927 .929277 .92902 .929277 .92902 .929277
11 12 18 14 15 16 17 18 19 20	.15865 .15881 .15396 .15412 .15427 .15443 .15458 .15474 .15489 .15505	.18155 .18176 .18198 .18220 .18241 .18263 .18285 .18307 .18328 .18350	.16308 .16324 .16340 .16355 .16371 .16387 .16403 .16419 .16435 .16451	.19485 .19508 .19531 .19554 .19576 .19599 .19622 .19645 .19668 .19691	.17276 .17292 .17308 .17325 .17341 .17357 .17374 .17390 .17407	.20983 .20907 .20931 .20955 .20979 .21003 .21027 .21051 .21075 .21099	.18269 .18326 .18302 .18379 .18336 .18353 .18369 .18386 .18403 .18420	.22352 .22377 .22402 .22428 .22453 .22478 .22503 .22528 .22554 .22579
21 22 23 24 25 26 27 28 29 29	.15520 .15536 .15552 .15567 .15583 .15598 .15614 .15630 .15645 .15661	.18572 .18394 .18416 .18487 .18459 .18481 .18503 .18525 .18547 .18569	.16467 .16483 .16499 .16515 .16581 .16547 .16563 .16579 .16595	.19718 .19736 .19759 .19782 .19805 .19828 .19851 .19874 .19897 .19920	.17499 .17456 .17472 .17489 .17505 .17522 .17538 .17554 .17571	.21128 .21147 .21171 .21195 .21220 .21244 .21268 .21292 .21316 .21341	.18437 .18454 .18470 .18487 .18504 .18521 .18538 .18555 .18572 .18588	.22604 .22629 .22655 .22680 .22706 .22731 .22756 .22782 .22807 .22633
31 33 33 34 35 36 37 38 89 40	.15676 .15692 .15708 .15728 .15739 .15755 .15770 .15786 .15802 .15818	.18591 .18613 .18635 .18657 .18679 .18701 .18723 .18745 .18767	.16627 .16644 .16660 .16676 .16692 .16708 .16724 .16740 .16756 .16772	.19944 .19967 .19990 .20013 .20086 .20059 .20083 .20106 .20129 .20152	.17604 .17620 .17637 .17653 .17670 .17686 .17708 .17719 .17736 .17752	.21365 .21389 .21414 .21438 .21462 .21487 .21511 .21535 .21560 .21584	.18605 .18622 .18639 .18656 .18673 .18690 .18707 .18724 .18741	.22858 .22884 .22909 .22935 .22960 .22986 .23012 .23037 .23063 .23089
41 42 43 44 45 46 47 48 49 50	.15833 .15849 .15865 .15890 .15896 .15912 .15923 .15943 .15959 .15975	.18812 .18834 .18836 .18878 .18901 .18923 .18945 .18967 .18990 .19012	.16788 .16805 .16821 .16837 .16853 .16869 .16885 .16902 .16918 .16934	.20178 .20199 .20222 .20246 .20269 .20292 .20316 .20339 .20363 .20386	.17769 .17786 .17802 .17819 .17835 .17852 .17868 .17885 .17902 .17918	.21609 .21638 .21658 .21682 .21707 .21731 .21756 .21781 .21805 .21830	.18775 .18792 .18909 .18826 .18843 .18860 .18877 .18894 .18911 .18928	.23114 .23140 .23166 .23192 .23217 .23243 .23269 .23295 .23321 .23847
51 58 58 54 55 56 57 58 59 60	.15991 .16006 .16022 .16038 .16054 .16070 .16085 .16101 .16117 .16193	.19034 .19057 .19079 .19102 .19124 .19146 .19169 .19191 .19214 .19226	.16950 .16966 .16983 .16999 .17015 .17081 .17047 .17064 .17080 .17096	.20410 .20433 .20457 .20480 .20504 .20527 .20551 .20575 .20598 .20622	.17985 .17952 .17968 .17965 .18001 .18018 .18055 .18051 .18068 .18068	.21855 .21879 .21904 .21929 .21958 .21978 .22008 .22028 .22058 .22077	.18945 .18962 .18979 .18996 .19018 .19080 .19047 .19064 .19081 .19098	.23873 .23399 .23424 .23450 .23476 .23502 .23529 .23559 .23581 .23607

,	3	6•	8	7°	8	8•	8	9•	
	Vers.	Ex. sec.	Vers.	Ex. sec.	Vers.	Ex. sec.	Vers.	Ex. sec.	
0	.19098 .19115	.23607	.90186 .90154	.25214	.21199	.26902 .26931	.22285 .22304	.28676	0
2	.19133	.28659	.20171	.25269	.21217 .21285	.26960	.22322	.28706 .28737	اة
ã	.19150	.23685	.20189	25296	.21258	.26988	.22340	.28767	2 8
4	.19167	.23711	.20207	.25324	.21271	.27017	.22859	.28797	4
5	.19184	.23738	.20224	.25851	.21289	.27046	.22377	.28828	5 6 7 8
6	.19201 .19218	.23764	.20242	.25879	.21807	.27075	.22395	.28858	5
8	.19235	.23790 .23816	.20277	.25406 .25434	.21824	.27104 .27133	.22414	.28889 .28919	١
ğ	.19252	23843	20294	25462	.21860	.27162	.22450	.28950	ğ
10	.19270	.23869	.20812	.25489	.21878	.27191	. 22469	.28980	10
11 12	.19287 .19304	.23895 .23922	.20829	.25517 .25545	.21896 .21414	.27221 .27250	.22487	.29011 .29042	11 12
19	.19321	.23948	.20865	.25572	.21482	.27279	.22524	.29072	18
14	.19338	.23975	.20382	.25600	.21450	.27808	.22542	.29103	14
15	.19356	.94001	.20400	.25628	.21468	.27887	.22561	.29133	15
16 17	.19873	.24028	.20417	.25656 .25683	.21486 .21504	.27866 .27896	.22579 .22598	.29164 .29195	16 17
18	.19407	.24081	.20453	.25711	.21522	.27425	.22616	.29226	18
19	.19424	.24107	20470	.25789	.21540	.27454	.22684	.29256	19
20	.19442	.24134	.20488	.25767	.21558	.27488	.29658	.29287	20
21	.19459	.24160	.90506	.25795	.21576	.27513	.22671	.29818	21
22 23	.19476 .19493	.24187 .24213	.20523	.25823 .25851	.21595 .21618	.27542 .27572	.22690	.29349 .29380	22 23
24	.19511	.24240	.20559	.25879	.21681	.27601	.22727	.29411	24
25	.19528	24267	.20576	.25907	.21649	.27630	.22745	29442	25
26	.19545	.24298	.20594	.25935	.21667	.27660	.22764	.29473	26
27	.19562	.24320	.20612	.25963	.21685	.27689	.22782	.29504	27
28 29	.19580 .19597	.24847	.20629	.25991 .26019	.21708 .21721	.27719 .27748	.22801 ,22819	.29535 .29566	28 29
80	.19614	.24400	.20665	.26047	.21789	.27778	.22838	.29597	80
81	.19632	.24427	.20682	.26075	.21757	.27807	.22856	.29628	81
82 83	.19649 .19666	.24454 .24481	.20700 .20718	.26104 .26132	.21775 .21794	.27837 .27867	.22875	.29659 .29690	82 83
84	1,684	.24508	20736	.26160	.21812	27896	22912	.29721	84
95	.19701	.24534	.20758	.26188	.21830	.27926	.22380	.29752	85
86 87	.19718	.24561	.20771	.26216	.21848	.27956	.22949	.29784	86
87	.19736	.24588	.20789	.26245	.21866	.27985	.22967 .22986	.29815	87 88
88 89	.1975 8 .19770	.24615 .21642	.20807 .20824	.26273 .26301	.21884	.28015 .28045	.23004	.29846 .29877	89
40	.19788	.24669	.20842	.26330	.21921	.28075	.23023	.29909	40
41	.19805	.94696	.20860	.26358	.21939	.28105	.23041	.29940	41
42 43	.19822 .19840	.24723 .24750	.20878 .20895	.26387 .26415	.21957 .21975	.28134 .28164	.28060	.29971 .30003	42
44	.19857	.24777	.20033	.26143	.21998	.28194	23079 23097	.80034	44
45	.19875	24804	.20931	26472	.22012	.28224	.23116	.80066	45
46	.19892	.24832	.20949	26500	.22030	.23254	.28134	.80097	46
47	.19909	.24859	.20967	.26529	.22048	.28284	.28158	.80129	47
48 49	.19927 .19944	.24886 .24913	.20985 .21002	.26557 .26586	.22066 .22084	.28314 .28344	.23172 .23190	.80160 .80192	48 49
50	.19944	.24913	.2102	.26615	.22103	.28374	.23209	.80228	50
51	.19979	.24967	.21038	.26648	.22121	.28404	.23228	.30255	51
52 53	.19997 .20014	.24995 .25022	.21056 .21074	.26672 .26701	.22139 .22157	.28484	.23246 .23265	.80237 .80818	52 53
54	.20014	.25022	.21074	.26729	.22176	.28495	.28283	.30350	54
55	.20049	.25077	.21109	.26758	.22194	.28525	,23302	.80882	65
KA	.20066	.25104	.21127	.26787	.22212	.28555	.23321	.80418	56 57
57 58	.20084	.25181	.21145	.26815	.22231	.28585	.23339	.80445	57
59	.20101 .20119	.25159 .25186	.21163 .21181	.26844 .26873	.22249 22267	.28615 .28646	.23358 .23377	.30477 .80509	58 59
60	.20136	.25214	.21199	.26902	.22285	.28676	.28896	.80541	60
			~					.uvzt '	•

11		4	.0°	4	.1° .	4	2°	4	3°	,
1		Vers.	Ex. sec.	Vers.	Ex. sec.	Vers.	Ex. sec.	Vers.	Ex. sec.	
2 . 33483 . 30065 . 24567 32508 . 32508 . 32544 . 34684	0			.24529	.82501					
4 .29470 .30068					32568					
4 .29470 .30068	ã									ã
6 28506 30732 24644 32703 28602 34775 28604 38953 7 7 28527 30704 24663 32737 28522 34911 27004 38993 7 8 28545 30796 24683 32770 25641 34346 27024 37030 8 9 22564 80229 24701 32204 25601 34823 27043 37080 8 10 22583 30861 24720 28288 25601 34823 27043 37080 8 11 22602 30898 24729 32873 25600 34953 27083 37100 10 11 22602 30898 24739 328973 25000 34953 27083 37100 10 11 22602 30898 24737 328905 25620 34968 27103 37180 10 11 22602 30898 24737 328905 25620 34968 27103 37180 11 12 23620 30896 24737 328905 25620 34968 27103 37180 11 13 23638 30867 24778 32899 25620 34968 27103 372818 13 14 22658 30969 24737 328973 25659 35040 27143 372218 13 15 23677 31052 24616 33007 25078 35060 27143 372218 13 16 23606 31054 24835 33041 25098 35131 27483 37238 15 16 23606 31054 24835 33041 25098 35131 27483 37380 16 17 22714 31066 24854 33075 25078 35080 27163 37298 16 18 22738 31119 24874 33109 26037 35203 27223 37406 18 19 23712 31151 24603 33143 26056 35228 27243 37448 19 20 23771 31188 24912 33117 26076 36374 27208 37848 19 21 22700 31216 24931 33211 26096 35310 27283 37519 21 22 23700 31216 24970 33279 26115 35346 27303 37594 23 24 28365 31248 24650 33245 26115 35346 27303 37594 23 25 28263 31344 24650 33245 26115 35346 27303 37594 23 25 28264 31313 24690 33314 26154 35418 27363 37794 23 26 23874 31814 24670 33279 26135 35382 27323 37794 23 27 28303 31411 25047 33216 28313 35528 27323 37794 23 28 23824 31878 25067 33282 26115 35358 27403 37794 23 29 2371 3118 34990 33314 26154 35418 27363 37794 23 29 23874 31674 25095 33062 26483 3550 27483 37794 23 29 23874 3167 25201 33061 26371 38560 27403 37794 23 29 23874 3167 25201 33061 26371 38560 27403 37794 23 29 23874 3167 25201 33061 26371 38560 27403 37794 23 29 23874 31878 25067 33383 26367 28630 38652 27683 387974 23 29 23874 3143 25066 33451 26223 35550 27483 37798 20 24073 31748 25095 33060 25060 33061 26371 38560 27403 37794 23 2404 2305 3104 25259 33760 26384 26703 38794 38894 40 2418 31870 25259 33760 26384 36000 36070 27703 38949 40 2418 3190 31804 25423 34177 26686 3640	4	.23470	.30668		.82636		.84704			4
9	5									5
9	6				.32703					6
9			90708		89770					1
10	اۋا		.80829		32604					
19		.23583	.80861							10
18 .29689 .30687 .94778 .82989 .25079 .35973 .25059 .85060 .27143 .37218 13 16 .29677 .31022 .24816 .3007 .25078 .85005 .27143 .37235 15 16 .29666 .31064 .24864 .38075 .25078 .35131 .27183 .37380 17 16 .29733 .31119 .24874 .38109 .26037 .35203 .27223 .37408 17 19 .28723 .31151 .24603 .33143 .26056 .352.28 .27243 .37481 19 29723 .31515 .24603 .33143 .26076 .85274 .27283 .37481 19 29723 .3216 .24931 .33117 .26076 .85274 .27283 .37481 19 29124 .24863 .33143 .24650 .32245 .26115 .85346 .27083 .37762 .22 .28227 .	11		.80893	.24739						
14 23686 30969 24707 32973 25059 35060 27143 37255 16 15 23677 31082 24816 33007 25078 35065 27163 37289 15 16 23606 31064 24824 38001 25078 35181 27163 37380 16 17 23733 31119 24874 33109 26037 35203 27223 37400 18 29733 31151 24803 33143 26056 36223 27243 37401 18 290 22771 31183 24912 33177 26076 36273 37433 374481 19 21 23700 31216 24931 38211 26066 35310 27283 37591 21 22 228073 31248 24070 33279 26135 385892 27323 37594 23 28 23864 31313 24969 33314<			.80925		.82905					12
16 28677 31082 24916 83007 25078 35005 27163 37293 16 16 28606 31064 24853 38041 25098 35181 27163 37380 16 17 28714 31066 24854 38075 26017 35167 27203 37368 17 18 22733 31119 24874 38109 26037 385203 27223 37406 18 19 23771 31183 24912 33177 26076 38574 27263 37481 19 21 23700 31216 24950 33245 26115 38546 27838 37656 22 23 23827 31281 24950 33245 26115 38546 27838 37650 22 23 23827 31281 24969 3314 26115 3544 27363 37652 22 23 23826 31346 25008			.80957							
16 28806 81064 24835 83041 25008 85181 27483 37890 16 17 28714 31066 24854 33075 26017 85167 27203 37888 17 18 28723 31151 24874 38109 26037 35203 27223 37408 18 29 23771 31183 24912 33117 26076 38523 27243 37448 18 21 23703 31246 24931 33211 26066 35310 27283 37519 21 22 23803 31248 24500 33245 26115 38546 27303 37569 22 232827 31281 24970 33279 26135 35382 27323 37694 23 26227 23484 31318 24969 33314 26164 35418 27363 37769 25 296 23894 31346 25006 33348 26174 35418									97909	
17 28714 31066 24864 33075 26017 35167 27283 37368 1718 28733 3119 24874 33100 29037 35203 27223 37406 18 19 28752 31151 24803 33143 26056 35228 27243 37443 19 20 23771 31188 24912 33177 26076 385274 27283 37443 19 21 22700 31216 24931 33211 26066 38310 27283 37519 21 22 23853 31248 2400 33245 26115 35346 27383 377519 21 24 23846 31313 24969 33314 26154 3644 27868 37632 24 256 23864 31878 25007 33348 26174 36454 27368 37632 27 25 23824 31411 25047 3316 26213										
18		.23714	.81086	.24854	.33075	.26017	.85167	.27203	.87868	17
20 .23771 .31188 .24912 .33177 .26076 .85274 .27263 .37481 .20 21 .22700 .31216 .24931 .33211 .26096 .35310 .27283 .37515 .29 228.2363 .31248 .24550 .33245 .26115 .85346 .27693 .37556 .22 23 .23827 .31281 .24970 .33279 .26135 .35389 .27323 .37564 .23 24 .23846 .31313 .24969 .33314 .26144 .35418 .27343 .37632 .23 25 .23825 .31346 .25008 .33348 .26174 .35418 .27343 .37632 .23 26 .23824 .31378 .25027 .33262 .26104 .35430 .27233 .37766 .22 27 .23903 .31411 .25047 .33416 .26213 .35252 .27423 .37764 .27 28 .23922 .31443 .25066 .3451 .26213 .35502 .27423 .37764 .27 29 .23941 .31476 .25065 .34455 .2623 .35502 .27423 .37784 .27 29 .23941 .31476 .25065 .34455 .2623 .35502 .27423 .37784 .27 29 .23947 .31574 .25143 .33554 .26292 .385604 .27463 .37862 .29 23 .24016 .31007 .25162 .33022 .26331 .35779 .27503 .37966 .33 23 .24016 .31007 .25162 .33022 .26331 .35779 .27503 .37964 .33 24 .24035 .31672 .25201 .33691 .26371 .35815 .27563 .36951 .35763 .35961 .35779 .27543 .38012 .34404 .31672 .25201 .33691 .26371 .35815 .27563 .36905 .38661 .35779 .27543 .38012 .3440 .31897 .25229 .33765 .26300 .35852 .27583 .38089 .38165 .38677 .24149 .31897 .25297 .33890 .26490 .35691 .27643 .38165 .38444 .24265 .31936 .25237 .33804 .2649 .35607 .27703 .38165 .38444 .24265 .31936 .25366 .33984 .26409 .35697 .27703 .38165 .38444 .24265 .31936 .25366 .33984 .2649 .35697 .3640 .27763 .38899 .4419 .31897 .25237 .33804 .26409 .35697 .3640 .27763 .38899 .4419 .31897 .25237 .33804 .2649 .3660 .27763 .38897 .36666 .36400 .27763 .38897 .38864 .24206 .31936 .25452 .34142 .26667 .36686	18	.28733	.81119	.24874	.83109	.26037	.35203	.27223	.87406	18
21 .28700 .81216 .24931 .33211 .26006 .35310 .27283 .87519 21 29 .28633 .31248 .24500 .33245 .26115 .85346 .27603 .87566 .22 28 .28527 .31281 .24970 .33279 .26115 .85348 .27633 .87569 23 24 .28466 .31313 .24969 .33314 .26164 .85418 .27383 .377632 .24 25 .28264 .31878 .25027 .33238 .26114 .35404 .27383 .37708 .26 27 .28903 .31411 .25047 .33416 .26213 .35526 .27403 .37746 .27 29 .28923 .31443 .25066 .33451 .26213 .35538 .27443 .37746 .27 29 .28941 .31476 .25085 .33451 .26223 .38508 .27443 .37784 .28 30							35208	27248		
289 289C3 31248 24C50 33245 26115 85846 27903 87556 22 28 238C7 31281 24970 33279 26135 38382 27821 37594 23 24 23846 31318 24989 38314 26154 35416 27638 37708 24 25 23826 31878 25027 33382 26104 38404 27638 37708 20 27 23903 31411 25047 33416 28213 35226 27423 37746 27 29 23921 31476 25065 33451 28223 38508 27443 37746 27 29 23941 31476 25085 33453 28223 38508 27443 37784 28 30 23969 31504 25143 33554 28292 38670 27483 37886 32 31 23978 31574 25143				***************************************		•		••••		
28 283:27 31281 24970 38279 26135 38582 27823 37594 28146 38181 24969 33314 26135 38548 27843 37682 21 28 28 28265 31346 25008 33348 26174 36454 27863 37670 25 26 28 28924 318718 2908 33141 25008 33348 26174 36454 27363 37670 25 26 28 28924 31411 25047 33416 26134 35430 27483 37764 27 28032 31443 25066 33465 2623 35502 27423 37784 27 280411 31476 25065 33465 26233 35502 27443 37822 29 280411 31476 25065 33465 26232 35634 27463 37822 29 280411 31509 25104 33559 26372 35634 27463 37822 29 28077	21									
284 28646 31818 24969 33314 26154 36416 27343 37682 24 25 29605 31846 25008 32348 26174 36454 27368 37670 25 26 28824 31878 25027 32562 26104 35400 27083 37708 20 27 23903 31411 25047 33416 26233 35502 27423 37708 20 28 23922 31443 25066 33451 26233 35502 27423 37746 27 29 23941 31476 25065 33451 26233 35508 27443 37784 28 29 23941 31476 25065 33455 26233 35508 27443 37784 28 29 23941 31476 25104 33519 26272 35634 27463 37860 21 23978 31541 25124 33554 26232 35634 27463 37860 31 23978 31541 25124 33554 26232 35607 27503 37986 31 23978 31544 25143 33558 26312 35707 27503 37986 38 24016 31007 25162 33622 26331 35743 27523 37974 38 24004 31672 25201 33691 26371 35615 27563 38012 34 24005 31640 25182 33637 26371 35615 27563 38012 34 24002 31738 25240 33760 28410 35888 27603 38127 38 24111 31771 23259 33765 26300 35852 27683 38165 38 24110 31897 25278 33300 26449 35997 27663 38242 40 24149 31887 25397 33864 26469 36997 27663 38242 40 24149 31887 25397 33864 26469 36997 27663 38242 40 24187 31903 25336 33968 26548 36107 27723 38357 44 24244 33002 25394 34088 26568 36107 27723 38357 44 24244 33002 25394 34088 26568 36107 27723 38357 44 24244 33002 25394 34088 26568 36107 27723 38357 44 24268 31936 25375 34033 26588 36107 27723 38357 44 24268 31936 25375 3403 26588 36107 27723 38357 44 24268 31936 25375 3403 26588 36107 27723 38357 44 24268 31936 25375 3403 26588 36107 27723 38357 44 24268 31936 25375 3403 26588 36107 27723 38357 44 42425 31969 25375 3403 26588 36107 27723 38357 44 42425				94070				97899		93
95 .986,5 .81346 .95008 .83348 .26174 .85464 .27868 .87670 25 96 .28848 .81878 .85027 .33382 .26114 .85400 .27758 .87760 25 27 .28903 .81411 .25047 .33416 .26213 .85552 .27423 .37746 27 28 .28922 .83941 .4148 .25065 .83451 .96223 .35508 .27443 .87822 20 30 .28969 .31509 .25104 .33519 .26272 .35634 .27463 .37860 30 81 .29978 .31574 .25143 .33558 .26312 .35774 .27503 .37986 38 83 .24016 .31607 .25163 .33637 .26331 .85743 .27523 .37986 38 84 .44025 .31640 .25123 .33637 .26331 .35743 .27523 .37981 38										24
27 28903 314111 25047 33416 28013 352:6 27403 37746 27 29 28922 31443 25066 33451 262:3 35508 27423 37784 28 29 28941 31476 25085 33405 262:3 35508 27443 37784 28 30 23969 31574 25124 33554 26292 285670 27483 37980 33 31 23978 31574 25143 33558 26312 35707 27483 37986 33 32 23907 31574 25162 33622 26381 35707 27543 36912 3670 34 24063 31040 25162 33627 26351 35743 27523 37963 38 35 24073 31705 25200 33726 26301 35615 27563 38011 35 36 24073 31738 25240 <th>25</th> <th></th> <th>.81346</th> <th></th> <th></th> <th></th> <th>.35454</th> <th>.27363</th> <th></th> <th>25</th>	25		.81346				.35454	.27363		25
29 .28941 .81476 .25085 .83425 .26223 .35598 .27443 .87822 .87860 20 31 .23978 .81541 .25124 .33554 .26272 .85634 .27463 .87860 20 32 .23997 .81574 .25143 .33558 .26312 .85707 .27603 .37986 31 33 .24016 .31040 .25162 .30627 .26311 .35779 .27523 .3794 .33 34 .24035 .81040 .25162 .33637 .26311 .35779 .27543 .3794 .33 35 .24043 .31672 .25201 .33761 .26371 .35615 .27563 .38012 .34 36 .24073 .31765 .25220 .33726 .26301 .35888 .27603 .38127 .37 37 .24092 .31738 .25220 .33736 .26410 .35888 .27603 .38127 .37	26	.23884						.27083		26
29 .28941 .81476 .25085 .83425 .26223 .35598 .27443 .87822 .87860 20 31 .23978 .81541 .25124 .33554 .26272 .85634 .27463 .87860 20 32 .23997 .81574 .25143 .33558 .26312 .85707 .27603 .37986 31 33 .24016 .31040 .25162 .30627 .26311 .35779 .27523 .3794 .33 34 .24035 .81040 .25162 .33637 .26311 .35779 .27543 .3794 .33 35 .24043 .31672 .25201 .33761 .26371 .35615 .27563 .38012 .34 36 .24073 .31765 .25220 .33726 .26301 .35888 .27603 .38127 .37 37 .24092 .31738 .25220 .33736 .26410 .35888 .27603 .38127 .37	27				.83416					27
30	28				99405					28
88 .28997 .31574 .25143 .33558 .26312 .35707 .27503 .37963 .37964 .38 .24016 .31007 .25162 .33023 .26311 .35779 .27503 .37974 .38 .24025 .31040 .25162 .33057 .26351 .35779 .27543 .38012 .34 .24024 .31672 .25201 .33726 .26311 .35779 .27543 .38012 .34 .240073 .31705 .25220 .33726 .26300 .36582 .27683 .38012 .37 .38089 .36 .24073 .31738 .25220 .33726 .26300 .35682 .27683 .380127 .37 .38 .24111 .31771 .25259 .33736 .26400 .35024 .27623 .38127 .37 .38 .24110 .31804 .23278 .33830 .26449 .35061 .27633 .38127 .37 .38 .24140 .31887 .25297 .33844 .26469 .35997 .27663 <										80
88 .28997 .31574 .25143 .33558 .26312 .35707 .27503 .37963 .37964 .38 .24016 .31007 .25162 .33023 .26311 .35779 .27503 .37974 .38 .24025 .31040 .25162 .33057 .26351 .35779 .27543 .38012 .34 .24024 .31672 .25201 .33726 .26311 .35779 .27543 .38012 .34 .240073 .31705 .25220 .33726 .26300 .36582 .27683 .38012 .37 .38089 .36 .24073 .31738 .25220 .33726 .26300 .35682 .27683 .380127 .37 .38 .24111 .31771 .25259 .33736 .26400 .35024 .27623 .38127 .37 .38 .24110 .31804 .23278 .33830 .26449 .35061 .27633 .38127 .37 .38 .24140 .31887 .25297 .33844 .26469 .35997 .27663 <	81	.23978	.81541	.25124	.33554		.85670	.27483	.87898	81
84 .94035 .81040 .25182 .83057 .96851 .85779 .27548 .88012 .84 85 .24064 .31072 .25201 .33091 .26871 .28815 .27563 .38012 .84 86 .24073 .81706 .25220 .33786 .28300 .35852 .27583 .38089 .88 87 .24002 .31738 .25240 .33760 .26410 .35868 .27603 .38127 .87 88 .24111 .31771 .25239 .33765 .26400 .35061 .27643 .38165 .38 39 .24180 .31804 .25278 .33830 .26449 .35961 .27643 .38204 .39 40 .24149 .31870 .25317 .33899 .26489 .36034 .27683 .38204 .30 41 .24168 .31870 .25317 .33899 .26489 .36034 .27683 .38242 40 42								.27503		82
85 24054 31672 25201 33691 26871 28515 27563 38051 35 86 24073 31706 25220 33736 26300 35852 27583 380980 38 87 24002 31738 25240 33760 26410 35988 27603 38127 37 88 24111 31771 25259 33380 26430 35024 27623 38163 38167 38204 39 34180 31894 25278 33530 26449 35061 2763 38204 39 41180 31897 25377 33864 26469 35997 27663 38242 40 41 24168 31870 25317 33890 26469 36949 27683 38242 40 41 24187 31903 25336 33968 26509 36070 27723 38319 42 42 24187 31936 25356 33968 <td< th=""><th></th><th></th><th></th><th></th><th></th><th>.26331</th><th></th><th>.27523</th><th></th><th></th></td<>						.26331		.27523		
36 24073 31705 25220 35726 26900 35858 27683 38089 38089 37 24002 31738 25240 35760 28410 35858 27608 38127 37 38 24111 31771 25259 33795 26450 35924 27623 38165 38 40 24140 31897 25278 38830 26449 35951 27623 38942 40 41 24168 31870 25317 33899 26489 36034 27683 389242 40 41 24168 31896 25336 38984 28609 36070 27703 38919 42 24187 31936 25356 38964 26698 36070 27773 38937 43 3414 24225 31969 25375 34003 26548 36143 27743 38937 43 44 24225 31969 25375 34038 26548 36143	95									98
87 24002 31738 25240 33760 26410 38588 27603 38127 3788 88 24111 31771 25259 33765 26460 35924 27623 38165 38 39 24140 31804 25278 33830 26449 35961 27623 38242 40 40 24149 31887 25297 33844 28469 35967 2703 38242 40 41 24168 31870 25317 33899 26489 36084 27683 38242 40 42 24187 31903 25336 33968 26529 36070 27703 38319 42 43 24206 31936 25356 33968 26528 36107 27723 38357 34 44 24205 31969 25375 34003 26528 36107 27734 38357 43 45 24244 32002 25394			.81705							86
80 .94130 .81804 .25278 .33830 .98449 .85661 .27648 .88204 .8940 40 .24149 .31877 .25297 .33864 .28409 .85997 .27663 .88243 .894 41 .24168 .31870 .25317 .38899 .26489 .86084 .27683 .88289 .44 42 .24187 .31908 .25363 .33984 .26509 .36070 .27723 .88319 42 43 .24206 .31936 .25356 .38968 .26528 .86107 .27723 .38359 44 44.2225 .31969 .25375 .34003 .26548 .86143 .27743 .38359 44 4.2244 .32003 .25344 .34073 .26588 .36180 .27764 .38434 45 4.45 .24262 .32068 .25413 .34108 .26687 .36207 .27784 .38434 45 47 .24281 .3	87	.24092			.83760					
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44 .94225 .81969 .25575 .84003 .26648 .86143 .27743 .83896 .444 .824244 .8003 .25364 .34068 .26648 .86180 .27764 .88434 .4546 .446 .24283 .38085 .25414 .84073 .36588 .36217 .27784 .88473 .46 .47 .24281 .28068 .25433 .84108 .26007 .36253 .27804 .38512 .47 .48 .24300 .38101 .25452 .34142 .26627 .36230 .27824 .38550 .48 .49 .24330 .3184 .25472 .34177 .26647 .36327 .27844 .38529 .49 .4339 .23168 .25491 .34212 .26667 .86303 .27864 .38628 50 51 .24358 .32201 .25511 .34247 .26686 .36400 .27884 .38666 51 58 .24306 .38267 .25549 .34317 .26736 .38417	48	.24206	.81936	.25856		.26528		.27728	.88857	43
45 .94244 .39002 .25394 .34088 .93668 .86180 .27764 .38434 .84684 .34688 .98217 .27784 .38434 .46 .24281 .39068 .25414 .34073 .26868 .36217 .27784 .38434 .46 .24281 .39068 .25433 .84108 .26607 .36253 .27894 .38512 47 .48 .24300 .38134 .25452 .34142 .26607 .36290 .27824 .38550 49 .43230 .38134 .25472 .34177 .26647 .36327 .27844 .38559 49 50 .24339 .32168 .25491 .34212 .26667 .36303 .27884 .38608 50 51 .24358 .32201 .25511 .34247 .26708 .36437 .27005 .38744 53 53 .24306 .38267 .25549 .34317 .26736 .86474 .37005 .38744 53	44	.24225	.81969	.25375	.84003	.26548		.27743		44
47 .24281 .39068 .25433 .84108 .26607 .36253 .27904 .38512 47 48 .24300 .38101 .25452 .34142 .26027 .36290 .37824 .38559 49 49 .24320 .32184 .25472 .34177 .26647 .36327 .27844 .38559 49 50 .24339 .82168 .25491 .34212 .26667 .36363 .27864 .38628 50 51 .24358 .32201 .25510 .34247 .26708 .36400 .27894 .38666 51 53 .24306 .38267 .25549 .34317 .26736 .86477 .27005 .38744 53								.27764		
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50 .24339 .82168 .25491 .84212 .28667 .86363 .27864 .88628 50 51 .24358 .82201 .95511 .84247 .26686 .36400 .27884 .88666 51 59 .24377 .32234 .25530 .34282 .26706 .86437 .27005 .88705 52 58 .24306 .88267 .25549 .34317 .26736 .86474 .37005 .38744 58		.24320					.86327		.88589	49
58 .24377 .32284 .2530 .34282 .26706 .86437 .27005 .88705 52 58 .24306 .82267 .2549 .84317 .26726 .86474 .27025 .88744 58		.24339		.25491		.26667	.86363	.27864	.88628	50
08 24:577 32:234 25:030 33:233 26:706 38:437 27:005 387:04 58:704	51									
54 .24415 .83301 .25569 .34352 .26746 .36511 .27045 .88783 54 55 .24418 .32384 .25588 .34387 .26768 .36548 .27905 .38822 55 56 .24453 .32368 .25608 .34423 .26785 .36585 .27905 .38822 55 57 .24473 .38401 .25627 .24438 .26805 .36602 .29005 .38596 57 58 .24491 .32484 .25647 .34493 .26825 .36659 .28026 .38038 58 59 .24510 .23468 .25696 .34528 .28645 .36596 .28046 .38097 59	58			95540						
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56 .24458 .82368 .25608 .84423 .26785 .36585 .27985 .38900 56 57 .24473 .83401 .25027 .34458 .28805 .36022 .29005 .38509 58 58 .24491 .38484 .25647 .34493 .26825 .36599 .29026 .389038 58 59 .24510 .38468 .25666 .84528 .26825 .36696 .28046 .88077 59	55	.24434	.82334	.25588	.34387	.26766	.86548	.27965	.88822	55
67 .24473 .30401 .25027 .34458 .26805 .36022 .28005 .38599 .56 .58 .24410 .32434 .25647 .34408 .26825 .36599 .28026 .38038 58 59 .24510 .38468 .25666 .34528 .28845 .36696 .28046 .38077 59	56									56
59 .24510 .83468 .25666 .34528 .26845 .36666 .28046 .88977 59	57									57
0000 00000 00000 00000 00000 00000	DO	04510	89468							59
 60 .245 25 .28668 .26865 .26865 .26865 .28066 .28066 .39016 60	60	.24529	82501	.25686	.84568	26865	.86738	.28066	.89016	60

	4	4.	4	.5°	4	6 •	4	7°	
	Vers.	Ex. sec.							
0	.28066	.39016	.29289	.41421	.80584	.43956	.81800	.46628	0
1 2	.28066 .28106	.89055 .89095	.29310 .29330	.41468 .41504	.80555 .80576	.43999 .44042	.81821 .81843	.46674 .46719	1 2
8	.28127	.89134	.29351	.41545	.80597	.44086	.31864	.46765	8
4	.28147	.89178	.29372	.41586	.30618	.44129	.81885	.46811	4
1 5	.28167	.89212	.29392	.41627	.30639	.44178	.81907	.46857	5
6	.28187	.89251	.29418	.41669	.30660	.44217	.81928	.46908	6
8	.28208	.89291 .89330	.29433	.41710 .41752	.30681 .30702	.44260 .44304	.81949 .81971	.46949 .46995	8
9	.28248	.39369	.29475	.41793	.30723	.44347	.81992	.47041	ğ
10	.28268	.89409	.29495	.41835	.30744	.44391	.32013	.47087	10
1 11	.28289	.89448	.29516	.41876	.30765	.44435	.82035	.47134	11
12	.28309	.89487	.29537	.41918	.80786	.44479	.82056	.47180	12
18	.28329	.39527	.29557	.41959	.80807	.44523	.82077	.47226	13
14 15	.28350 .28370	.89566 .89606	.29578	.42001 .42042	.30828	.44567 .44610	.32099 .32120	.47272 .47819	14 15
16	.28390	.39646	.29619	42084	.80870	.44654	.82141	47365	16
17	.28410	.89685	.29640	.42126	.80891	.44698	.82163	.47411	17
18	.28431	.89725	.29661	.42168	.80912	.44742	.82184	.47458	18
19 20	.28451 .28471	.39764 .39804	.29681 .29702	.42210 .42251	.30933 .30954	.44787	.82205	.47504 .47551	19 20
1									
21 22	.28492 .28512	.39844 .39884	.29723	.42293 .42335	.30975	.44875 .44919	.32248	.47598 .47644	21 22
23	.28532	.39924	.29764	.42377	.81017	.44963	.82291	.47691	23
24	.28553	.39963	.29785	.42419	.81038	.45007	.32312	.47738	24
25	.28573	.40008	.29905	.42461	.81059	.45052	.32334	.47784	25
26 27	.28593 .28614	.40043 .40083	.29826	.42508 .42545	.81080	.45096 .45141	.82355	.47831 .47878	26 27
28	.28634	.40123	.29868	.42587	.81101 .81122	.45185	.32398	47925	28
29	.28655	.40163	.29888	.42630	.81143	.45229	.82420	47972	29
80	.28675	.40208	.29909	.42672	.81165	.45274	.82441	.48019	30
81	.28695	.40243	.29930	.42714	.81186	.45319	.82462	.48066	81
32 33	.28716	.40288	.29951	.42756	.81207	.45363	.82484	.48118	32
84	.28786 .28757	.40324 .40364	.29971	.42799 .42841	.31228 .31249	.45408 .45452	.82505 .82527	.48160 .48207	83 84
85	.28777	.40404	.30013	.42883	.81270	45497	.32548	.48254	35
86 87	.28797	.40444	.30034	.42926	.81291	.45542	.82570	.48301	26
87	.28818	.40485	.80054	.42968	.81812	.45587	.32591	.48349	87
89	.28838 .28859	.40525 .40565	.80075	.43011 .43053	.81834 .81855	.45631 .45676	.82618 .32634	.48396 .48443	38 39
40	.28879	.40606	.80117	.43096	.81876	.45721	.32656	.48491	40
41	.28900	.40646	.80138	.43139	.81397	.45766	.82677	.48538	41
42	.28920	.40687	.30158	.43181	.81418	.45811	.82699	.48586	42
43	.28941	.40727	.80179	.43224	.81439	.45856	.82720	.48633	43
44	.28961 .28981	.40768 .40808	.80200 .80221	.43267 .43310	.81461 .81482	.45901 .45946	.32742 .32763	.48681 .48728	44 45
46	.29002	.40849	.80221	.43359	.81503	.45990	.82785	.48776	46
47	.29022	.40890	.80263	.43395	.81524	.46037	.32806	.48824	47
48	.29048	.40930	.30288	.43438	.81545	.46082	.32828	.48871	48
49 50	.29063 .29084	.40971 .41012	.80304 .80325	.43481 .43524	.81567 .31588	.46127 .46173	.32849 .82871	.48919 .48967	49 50
51	.29104	.41058	.80346	.43567	.81609	.46218	.82893	.49015	51
52	.29125	.41098	.80367	.43610	.81630	.46263	.82914	.49063	52
53 54	.29145 .29166	.41184 .41175	.30388	.43658 .43696	.31651 .31678	.46309 .46354	.32936 .82957	.49111	53 54
55	.29187	.41216	.80430	.43739	.81694	.46400	32979	.49159	55
56	.29207	.41257	.80451	.43783	.81715	.46445	.83001	.49255	KR
57	.29228	.41298	.80471	.43826	.81786	.46491	.83022	.49303	57
58	.29248	.41339 .41380	.30492 .30513	.43869 .43912	.31758	.46587 .46582	.83044 .33065	.49351 ,49399	57 58 59
60	.29289	.41421	.30534	.43956	.31800	.46628	.83087	.49448	60
				. 2000	.02000			. 20120	

	4	18°	4	9•	5	0•	5	1•	,
	Vers.	Ex. sec.	•						
0	.33087 .33109	.49448 .49496	.34394 .34416	.52425 .52476	.85721 .35744	.55572 .55626	.37068 .37091	.58902 .58959	0
اۋا	.33130	49544	.34438	.52527	.35766	.55680	.37113	.59016	2
2	.33152	.49593	.84460	.52579	.35788	.55784	.37136	.59073	2
4	.33173	.49641	.34482	.52630	.35810	.55789	.87158	.59130	4
5	.33195	.49690	.34504	.52681	.35833	.55843	.37181	.59188	5 6 7
6	.33217	.49738	.34526	.52732	.35855	.55897	.87204	.59245	6
7	.33238	.49787	.34548	.52784	.85877	.55951	.37226	.59302	7
8	.83260	.49835	.34570	.52835	.85900	.56005	.37249	.59360	8
9 10	.83282 .33303	.49884 .49933	.84592 .84614	.52886 .52938	.35922 .35944	.56060 .56114	.87272 .87294	.59418 .59475	9 10
11	.83325 .33347	.49981 .50030	.34636 .34658	.52989 .53041	.35967 .35989	.56169 .56223	.87817	.59533	11
12 13	.33368	.50079	.34680	.53092	.36011	.56278	.37340 .37362	.59590 .59648	12 13
14	.33390	.50128	.84702	.53144	.36034	.56332	.87385	.59706	14
15	.33412	.50177	.34724	.53196	.36056	.56387	.87408	.59764	15
16	.83434	.50226	.84746	.53247	.36078	.56442	.37430	.59822	16
17	.83455	.50275	.84768	.53299	.36101	.56497	.87458	.59880	17
18	.33477	.50324	.84790	.53351	.36123	.56551	.87476	.59938	18
19 20	.83499 .83520	.50378 .50422	.34812 .34834	.53403 .53455	.36146 .36168	.56606 .56661	.37498 .37521	.59996 .60054	19 20
21	.33542	.50471	.34856	.53507	.36190	.56716	.87544	.60112	21
22	.33564	.50521	.34878	.53559	.36213	.56771	.37567	.60171	22
23	.33586	.50570	.84900	.53611	.36235	.56826	37589	60229	23
24	.33607	.50619	.84923	.53663	.36258	.56881	.87612	.60287	24
25	.33629	.50669	.84945	.53715	.36280	.56937	.87685	.60346	25
26	.33651	.50718	.34967	.53768	.36302	.56992	.37658	.60404	26
27 28	.83678	.50767	.34989	.53820	.36325	.57047	.37680	.60463	27
29	.33694 .33716	.50817 .50866	.85011 .85033	.53872 .53924	.36347 .36370	.57103 .57158	.37703 .37726	.60521 .60580	26 27 28 29
80	.83738	.50916	.85055	.53977	.36392	.57218	.87749	.60639	30
81	.88760	.50966	.35077	.54029	.36415	.57269	.37771	.60698	81
82	.33782	.51015	.85099	.54082	.36437	.57324	.87794	.60756	82 83
83	.33803	.51065	.35122	.54134	.86460	.57380	.37817	.60815	
84 85	.33847	.51115 .51165	.35144 .35166	.54187 .54240	.36482 .36504	.57436 .57491	.37840 .37862	.60874	84 85
36	.33869	.51215	.35188	.54292	.36527	.57547	.37885	.60992	86
87	.33891	.51265	.85210	.54845	.36549	.57603	.37908	.61051	87
38	.83912	.51314	.85232	.54398	.36572	.57659	.37931	.61111	38
39	.83934	.51364	.35254	.54451	.36594	.57715	.37954	.61170	89
40	.83956	.51415	.35277	.54504	.36617	.57771	.87976	.61229	40
41	.83978	.51465	.35299	.54557	.36639	.57827	.37999	.61288 .61348	41 42
42 43	.34000 .34022	.51515 .51565	.85321	.54610 .54663	.36662 .36684	.57939	.38022	.61407	43
44	.84044	.51615	.35365	.54716	.86707	.57995	.38068	.61467	44
45	.34065	.51665	.35388	.54769	.36729	.58051	.38091	.61526	45
46	.84087	.51716	.85410	.54822	.86752	.58108	.38113	.61586	46
47	.84109	.51766	.85432	.54876	.86775	.58164	.88186	.61646	47
48	.84181	.51817	.35454	.54929	.86797	.58221	.88159	.61705	48
49 50	.84158 .84175	.51867 .51918	.35476 .85499	.54982 .55086	.36820 .36842	.58277 .58333	.38182 .38205	.61765 .61825	49 50
51	.84197	.51968	.85521	.55089	.86865	.58390	.38228	.61885	51
52 58	.84219 .84241	.52019 .52069	.85548 .85565	.55143	.36887 .36910	.58447	.88251 .88274	.61945	52
54	.84262	.52120	.85588	.55196 .55250	.86932	.58503 .58560	.88296	.62005 .62065	53 54
55	.84284	.52171	.85610	.55303	.86955	.58617	.38319	.62125	55
56	.84306	52222	.85632	.55357	.86978	.58674	.38342	.62185	56
57	.84328	.52273	.35654	.55411	.87000	.58731	.38365	.62246	55 56 57
58	.84850	.52323	.85677	.55465	.87023	.58788	.38388	.62306	58
59	.84872	.52374	.85699+	.55518	.87045	.58845	.88411	.62366	59
60	.84394	.52425	.35721	.55572	.37063	.58902	.38434	.62427	60

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	Vers.	Ex. sec.	Vers.	Ex. sec.	Vers.	Ex. sec.	Vers.	Ex. sec.	
0	.88484	.69427	.89819	.66164	.41221	.70180	.42642	.74845	0
1 2	.88457 .88480	.62487 62548	.89842 .89865	.66228 .66292	.41245	.70198 .70267	.42666	.74417	1
8	.38508	.62609	.89888	.66357	.41209	.70385	.42714	.74490 .74562	2
4	.88526	.62669	.89911	.66421	.41816	.70403	.42738	.74685	4 5
5	.88549	.62730	.89935	.66486	.41839	.70472	.42762	.74708	5
6 7	.88571 .88594	.62791 .62852	.89958 .89981	.66550 .66615	.41368	.70540 .70609	.42785	.74781 .74854	6
8	.88617	.62918	.40005	.66679	.41410	.70677	.42833	74927	8
9	.88640	.62974	.40028	.66744	.41488	.70746	.42857	.75000	9
10	.38663	.63085	.40051	.66809	.41457	.70815	.42881	.75073	10
11	. 38686	.63096	.40074	.66878	.41481	.70884	.42905	.75146	11
12 18	.88709 .88732	.63157 .68218	.40098 .40121	.66988 .67008	.41504 .41528	.70953 .71022	.42929	.75219 .75293	12 13
14	.88755	68279	.40144	.67068	.41551	.71091	.42976	.75866	14
15	.88778	.63341	.40168	.67188	.41575	71160	.43000	.75440	15
16	.88801	.63402	.40191	.67199	.41599	.71229	.43624	.75513	16
17	.88824 .88847	.68464 .68525	.40214	.67264 .67329	.41622 .41646	.71298 .71368	.43048	.75587 .75661	17 18
19	.88870	.63587	.40261	.67394	.41670	.71487	.43096	.75734	19
20	.38898	.63648	.40284	.67460	.41693	.71508	.43120	.75808	20
21	.38916	.63710	.40307	.67525	.41717	.71576	.43144	.75882	21
22	.38939	.63772	.40331	.67591	.41740	.71646	.43168	.75936	22
28	. 38962 . 38965	.63884	.40354	.67656	.41764	.71716	.48192	.76081	23
25	.89009	.63895 .63957	.40378	.67722 .67788	.41788	.71785	.43216	.76105 .76179	24 25
26	.89082	.64019	.40424	.67858	.41835	.71925	.43264	.76253	26
27	.89055	.64081	.40448	.67919	.41859	.71995	.43287	.76328	26 27
28	.89078	.64144	.40471	.67985	.41882	.72065	.43311	.76402	28
29 30	.89101 .89124	.64206 .64268	.40494 .40518	.68051 .68117	.41906 .41980	.72185 .72205	.43385 .43359	.76477 .76552	29 30
81	.89147	.64330	.40541	.68183	.41953	.72275	.43383	.76626	31
82	.89170 .39198	.64398 .64455	.40565	.68250 .68816	.41977	.72346 .72416	.48407	.76701 .76776	32 33
84	.39216	.64518	.40611	.68382	.42024	.72487	.48455	.76851	84
85	.39239	.64580	.40635	.68449	.42048	.72557	.48479	.76926	35
36	.39262	.64643	.40658	.68515	.42072	.72628	.43503	.77001	86
37 38	.39286 .39309	.64705 .64768	.40682	.68582 .68648	.42096 .42119	.72698 .72769	.43527	.77077	87 88
86	.39332	.64831	40728	.68715	.42148	.72840	.43575	.77152	89
40	. 39355	.64894	.40752	.68782	.42167	.72911	.43599	.77303	40
41 42	.89878 .89401	.64957	.40775	.68848	.42191	.72982	.43623	.77378	41 42
48	.89401	.65020 .65083	.40799 .40822	.68915 .68982	.42214	.73053 .73124	.43647	.77454	43
44	.39447	.65146	.40846	.69049	.42262	.78195	.43695	.77606	44
45	.39471	.65209	.40869	.69116	.42285	.73267	.48720	.77681	45
46	.39494 .39517	.65272	.40893	.69188 .69250	.42309	.73338	.43744	.77757	46
48	.39540	.65399	.40910	.69318	.42338	.73409 .73481	.43768	.77833	47
49	.39563	.65462	.40963	.69385	.42381	.73552	.43816	.77986	49
50	.89586	.65526	.40986	.69452	.42404	.73624	.43840	.78062	50
51 59	.89610 .89633	.65589 .65653	.41010 .41033	.69520 .69587	.42428	.73696 .73768	.43864	.78138 .78215	51 52
58	.89656	.65717	.41057	.69655	.42476	.78840	.43912	.78291	58
54	.89679	.65780	.41080	.69723	.42499	.73911	.43986	.78368	54
56	.39702	.65844	.41104	.69790	.42523	.78988	.43960	.78445	55
57	.89726 .89749	.65908 .65972	.41127 .41151	.69858 .69926	.42547	74056 .74128	.43984	.78521 .78598	56 57
58	.89772	.66036	.41174	.69994	.42595	74200	.44088	.78675	88
59	.89795	.66100	.41198	.70062	.42619	.74272	.44057	.78752	59
F 00 1	.89819	.66164	.41221	.70130	.42642	.74345	.44081	.78899	60

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′	Vers.	Ex. sec.							
0	.44081	.78829	.45536	.88608	.47008	.88708	.48496	.94160	0
1	.44105	.78906 .78984	.45560	.83690 .83773	.47088 .47057	.88796 .88884	.48521	.94254	1 2
2 8	.44129 .44158	79061	.45609	.83855	47082	.88972	.48571	.94448	8
4	.44177	.79138	.45634	.88938	.47107	.89060	.48596	.94537	I 4
5	.44201	.79216	.45658	.84020	.47181	.89148 .89237	.48621	.94632	5
6 7	.44225	.79293 .79371	.45683	.84103 .84186	.47156 .47181	.89325	.48646	.94726 .94821	7
8	.44274	.79449	.45781	.84269	.47206	.89414	.48696	.94916	8
9	.44298	.79527	.45756	.84352	.47280	.89503	.48721	.95011	9
10	.44322	.79604	.45780	.84435	.47255	.89591	.48746	.95106	10
11	.44846	.79682	.45805	.84518	.47280	.89680 .89769	.48771	.95201	11 12
12 18	.44870 .44895	.79761 .79839	.45829	.84601 .84685	.47304 .47329	.89858	.48796 .48821	.95392	13
14	.44419	.79917	.45878	.84768	47854	.89948	.48846	.95487	14
15	.44413	.79395	.45903	.84852	.47879	.90037	48871	.95583	15
16	.44467	.80074	.45927	.84935 .85019	.47403 .47428	.90126	.48896 .48921	.95678 .95774	16 17
17 18	.44491 .44516	.80152 .80231	.45951 .45976	.85103	.47453	.90305	.48946	.95870	18
19	.44540	.80809	.46000	.85187	.47478	.90395	.48971	.95966	19
20	.44564	.80388	.46025	.85271	.47502	.90485	.48996	.96062	20
21	.44588	.80467	.46049	.85355	.47527	.90575	.49021	.96158	21
22	.44612	.80546	.46074	.85439	.47552	.90665	.49046	.96255 .96351	22 23
23 24	.44637 .44661	.80625 .80704	.46098 .46123	.85523 .85608	.47577 .47601	.90755	.49071 .49096	.96448	24
25	.44685	.80783	.46147	.85692	.47626	.90935	.49121	.96544	25
26	.44709	.80862	.46172	.85777	.47651	.91026	.49146	.96641	26
27 28	.44734 .44758	.80942 .81021	.46196 .46221	.85861 .85946	.47676 .47701	.91116 .91207	.49171	.96738 .96835	27 28
29	.44782	.81101	.46246	.86081	.47725	.91297	.49221	.96932	29
ão.	.44806	.81180	.46270	.86116	.47750	.91388	.49246	.97029	80
31	.44831	.81260	.46295	.86201	.47775	.91479	.49271	.97127	31
82	.44855	.81340	.46319	.86286	.47800	.91570	.49296	.97224 .97322	32 33
83 84	.44879 .44903	.81419 .81499	.46344	.86371 .86457	.47825 .47849	.91661 .91752	.49321	.97420	34
85	.44928	.81579	.46393	.86542	.47874	.91844	.49372	.97517	35
86	.44952	.81659	.46417	.86627	.47899	.91935	.49397	.97615	36
87	.44976 .45001	.81740 .81820	.46442	.86718 .86799	.47924 .47949	.92027 .92118	.49422	.97713 .97811	87 38
88 89	45025	.81900	.46491	.86885	.47974	.92210	.49472	.97910	39
40	.45049	.81961	.46516	.86990	.47998	.92302	.49497	.98008	40
41	.45078	.82061	.46540	.87056	.48023	.92394	.49522	.98107	41
42	.45098	.82142	.46565	.87142	48048	.92486	.49547	.98205	42
48	.45122 .45146	.82222 .82303	.46589 .46614	.87229 .87315	.48073 .48098	.92578 .92670	.49572 .49597	.98304	43 44
44 45	.45171	.82384	.46639	.87401	.48123	.92762	.49623	.98502	45
46	.45195	.82465	.46663	.87488	.48148	.92855	.49623 .49648	.98601	46
47	.45219	.82546	.46688	.87574	.48172	.92947	.49678	.98700	47
48 49	.45244 .45268	.82627 .82709	.46712	.87661 .87748	.48197	.93040 .93138	.49698	.98799 .98899	48 49
50	45292	.82790	.46762	.87834	48247	.93226	.49748	.98998	50
51	.45317	.82871	.46786	.87921	.48272	.93319	.49778	.99098	51
52 58	.45841	.82953	.46811	.88008	.48297	.93412	.49799	.99198	52
58	.45365	.83034	.46836	.88095	.48347	.93505 .93598	.49824	.99298 .99398	58 54
54 55 56 57	.45390 .45414	.83116 .83198	.46860 .46885	.88188 .88270	.48347	.93692	.49874	.99498	55
56	.45489	.83280	.46909	.88357	.48396	.93785	.49899	99598	56
57	.45463	.83362	.46934	.88445	.48421	.93879	.49924	.99698	56 57 58
58	.45487	.83444	.46959	.88532 .88620	.48446 .48471	.93978	.49950 .49975	.99799	58 59
58 59 60	.45512 .45536	.83526 .83608	46983	.88708		.94160	.50000	1.00000	60
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	Vers.	Ex se	Vers.	Ex. sec.	Vers.	Ex. sec.	Vers.	Ex. sec.	'
0	.50000	1.00000	.51519	1.06267	.53053	1.13005	.54601	1.20269	0
1	.50025	1.00101	.51544	1.06375	.53079	1.13122	.54627	1.20395	1
2	.50050	1.00202	.51570	1.06483	.53104	1.13239	.54653	1.20521	2
8	.50076	1.00308	.51595	1.06592	.53130	1.13356	.54679	1.20647	8
4 5	.50101 .50126	1.00404	.51621	1.06701	.53156 .53181	1.13478	.54705	1.20773	5
6	.50151	1.00607	.51672	1.06918	53207	1.13707	.54757	1.21026	6
7	.50176	1.00708	.51697	1.07027	.53233	1.13825	.54782	1.21153	7
8	.50202	1.00810	.51728	1.07187	.53258	1.13942	.54808	1.21280	8
.9	.50227 .50252	1.00912	.51748	1.07246 1.07856	.53284	1.14060 1.14178	.54834	1.21407	10
10		1.01014	.51774			1 1			
11	.50277 .50303	1.01116	.51799	1.07465	.53336 .53361	1.14296 1.14414	.54886 .54912	1.21662	11 12
12 13	.50828	1.01218 1.01320	.51825	1.07575	.53387	1.14588	.54938	1.21918	13
14	.50353	1.01422	.51876	1.07795	.53418	1.14651	.54964	1.22045	14
15	.50378	1.01525	.51901	1.07905	.53439	1.14770	.54990	1.22174	15
16	.50404	1.01628	.51927	1.08015	.53464	1.14889	.55016	1.22302	16
17	.50429	1.01780	.51952	1.08126 1.08236	.53490	1.15008	.55042	1.22430	17 18
18 19	.50454 .50479	1.01833 1.01936	.51978	1.08347	.53542	1.15127	.55094	1.22688	19
20	.50505	1.02039	.52029	1.08458	.53567	1.15366	.55120	1.22817	20
21	.50530	1.02143	.52054	1.08569	.53503	1.15485	.55146	1.22946	21
22	.50555	1.02246	.52080	1.08680	.53619	1.15605	.55172	1.23075	22
23	.50581	1.02349	.52105	1.08791	.53645	1.15725	.55198	1.23205	23
24	.50606	1.02458	.52131	1.08903	.53670	1.15845	.55224	1.23334	24
25 26	.50631 .50656	1.02557 1.02661	.52156	1.09014 1.09128	.53696	1.15965	.55250 .55276	1.28464	25 26
27	.50682	1.02765	.52207	1.09238	.53748	1.16206	.55302	1.23724	27
28	.50707	1.02869	.52233	1.09350	.53774	1.16326	.55328	1.23855	28
29	.50732	1.02973	.52259	1.09462	.53799	1.16447	.55354	1.23985	29 30
80	.50758	1.03077	.52284	1.09574	.53825	1.16568	.55380	1.24116	1
81	.50783	1.03182	.52310	1.09686	.53851	1.16689	.55406	1.24247	31 82
32	.50808 .50834	1.03286 1.03391	.52335	1.09799	.53877	1.16810 1.16932	.55458	1.24509	33
34	.50859	1.03496	.52386	1.10024	.53928	1.17053	.55484	1.24640	34
35	.50884	1.03601	.52412	1.10137	.53954	1.17175	.55510	1.24772	35
36	.50910	1.03706	.52438	1.10250	53980	1.17297	.55536	1.24903	36
37	.50935 .50960	1.03811	.52463	1.10363	.54006 .54032	1.17419 1.17541	.55563	1.25085 1 25167	37 38
38 39	.50986	1.03916	.52514	1.10590	.54058	1.17663	.55615	1.25300	89
40	.51011	1.04128	.52540	1.10704	.54083	1.17786	.55641	1.25432	40
41	.51036	1.04233	.52566	1.10817	.54109	1.17909	.55667	1.25565	41
42	.51062	1.04339	.52591	1.10931	.54135	1.18031	.55693	1.25697	42
43	.51087	1.04445	.52617	1.11045	.54161	1.18154	.55719	1.25830	48
44	.51113	1.04551	.52642	1.11159 1.11274	.54187	1.18277	.55745	1.25963	44
45	.51138 .51163	1.04658 1.04764	.52668 .52694	1.11274	.54288	1.18524	.55797	1.26230	46
47	.51189	1.04870	.52719	1.11503	.54264	1.18648	.55823	1.26364	47
48	.51214	1.04977	.52745	1.11617	.54290	1.18772	.55849	1.26498	48
49	.51239	1.05084	.52771	1.11732	.54316	1.18895	.55876	1.26632	49 50
50	.51265	1.05191	.52796	1.11847	.54342	1.19019			1
51	.51290	1.05298 1.05405	.52822	1.11963	.54368 .54394	1.19144	.55928 .55954	1.26900	51 52
52 53	.51316 .51341	1.05405	52873	1.12078	.54420	1.19398	.55980	1.27169	58
54	.51366	1.05619	.52899	1.12309	.54446	1.19517	.56006	1.27804	54
55	.51392	1.05727	.52924	1.12425	.54471	1.19642	56032	1.27439	55
56	.51417	1.05835	.52950	1.12540	.54497	1.19767	.56058	1.27574	56
57 58	.51443 .51468	1.05942 1.06050	.52976	1.12657 1.12773	.54528	1.19892	.56084	1.27710 1.27845	57 58
59	.51494	1.06158	.53027	1.12889	.54575	1.20148	.56137	1.27981	59
lěöl	.51519	1.06267	.53053	1.13005		1.20269	.56163	1.28117	60

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1.	- 6	4.	6	50	6	6.	6	7°	,
	Vers.	Ex. sec.							
0	.56163	1.28117	.57788	1.86620	.59826	1.45859	.60927	1.55990	0
1 2	.56189 .56215	1.28253 1.28890	.57765	1.36768 1.36916	.59853	1.46020 1.46181	.60954 .60980	1.56106 1.56282	1 2
8	.56241	1.28526	.57817	1.37064	.59406	1.46342	.61007	1.56458	8
4	.56267	1.28663	.57844	1.37212	.59433	1.46504	.61084	1.56684	4
5	.56294 .56320	1.28800 1.28937	.57870 .57896	1.37361 1.37509	.59459 .59486	1.46665 1.46827	.61061 .61088	1.56811	5
7	.56846	1.29074	.57928	1.87658	.59512	1.46989	.61114	1.57165	7
8	.56872	1.29211 1.29349	.57949	1.37808	.59589	1.47152	.61141	1.57842	8
10	.56398 .56425	1.2949	.57976 .58002	1.37957	.59566	1.47814	.61168 .61195	1.57520 1.57698	10
11	.56451	1.29625	58028	1.38256	.59619	1.47640	.61222	1.57876	11
12	.56477	1 29763	.58055	1.88406	.59645	1.47804	.61248	1.58054	12
13	.56508	1.29901	.58081	1.88556	.59672	1.47967	.61275	1.58233	18 14
14 15	.56529	1.80040 1.80179	.58108 .58134	1.38707	.59699	1.48131 1.48295	.61802 .61829	1.58591	15
16	.56582	1.30818	.58160	1.39008	.59752	1.48459	.61856	1.58771	16
17 18	.56608 .56634	1.30457	.58187	1.39159	.59779	1.48624	.61888 .61409	1.58950	17 18
19	.56660	1.30735	.58213	1.39311 1.39462	.59832	1.48789 1.48954	.61436	1.59811	19
20	.56687	1.30875	.58266	1.39614	.59859	1.49119	.61463	1.59491	20
21	.56718	1.81015	.58293	1.39766	.59885	1.49284	.61490	1.59672	21
22 23	.56739 .56765	1.31155 1.31295	.58319 .58345	1.89918	.59912	1.49450	.61517 .61544	1.59853	22 23
24	.56791	1.31296	.58372	1.40070	.59965	1.49616 1.49782	.61570	1.60217	24
25	.56818	1.81576	.58398	1.40375	.59992	1.49948	.61597	1.60399	25
26	.56844 .56870	1.31717	.58425	1.40528	.60018	1.50115 1.50282	.61624 .61651	1.60581 1.60763	26 27
28	.56896	1.81858 1.31999	.58478	1.40681 1.40835	.60045	1.50282 1.50449	.61678	1.60946	28
29	.56923	1.82140	.58504	1.40988	.60098	1.50617	.61705	1.61129	29
80	.56949	1.82282	.58531	1.41142	.60125	1.50784	.61782	1.61818	80
81 82	.56975 .57001	1.82424 1.82566	.58557 .58584	1.41296 1.41450	.60152 .60178	1.50952 1.51120	.61759 .61785	1.61496 1.61680	81
83	.57028	1.32708	.58610	1.41430	.60205	1.51289	.61812	1.61864	83
84	.57054	1.32850	.58637	1.41760	.60232	1.51457	.61839	1.62049	84
85 86	.57080 .57106	1.32993 1.33135	.58663	1.41914	.60259	1.51626 1.51795	.61866 .61898	1.62234	85 86
87	.57183	1.33278	.58716	1.42225	.60312	1.51965	.61920	1.62604	87
88	.57159	1.83422	.58743	1.42380	.60339	1.52134	.61947	1.62790	38
39 40	.57185 .57212	1.83565 1.83708	.58769 .58796	1.42536 1.42692	.60365 .60392	1.52804 1.52474	.61974 .62001	1.62976 1.63162	89 40
41	.57288	1.83852	.58822	1.42848	.60419	1.52645	.62027	1.63348	41
42 43	.57264 .57291	1.33996	.58849	1.43005 1.43162	.60445 .60472	1.52815 1.52986	.62054 .62081	1.63535 1.63722	42 43
44	.57317	1.34284	.58902	1.43318	.60499	1.53157	.62108	1.63909	44
45	.57348	1.84429	.58928	1.43476	.60526	1.53329	.62185	1.64097	45
46	.57369 .57396	1.84578	.58955 .58981	1.43633 1.43790	.60552 .60579	1.53500	.62162 .62189	1.64285	46
48	.57422	1.84868	.59008	1.43948	.60606	1.53845	.62216	1.64662	48
49 50	.57448 .57475	1.85009 1.85154	.59034 .59061	1.44106 1.44264	.60659	1.54017 1.54190	.62248	1.64851	49 50
51	.57501	1.85800	.59087	1.44428	.60686	1.54868	.62297	1.65229	51
52	.57527	1.85446	.59114	1.44582	.60713	1.54536	62324	1.65419	52
58	.57554	1.85592	.59140	1.44741	.60740	1.54709	.62851	1.65609	53
54 55	.57580 .57606	1.85788	.59167	1.44900	.60766	1.54888	.62378	1.65799 1.65989	54 55
56	.57688	1.86031	.59220	1.45219	.60820	1.55231	.62431	1.66180	56
57 58	.57659 .57685	1.86178	.59247	1.45378 1.45539	.60847	1.55405	.62458 .62485	1.66371	57 58
59	.57712	1.86473	.59300	1.45699	.60973	1.55755	.62512	1.66755	59
60	.57788	1.86620	.59326	1.45859	.60927	1.55930	.62539	1.66947	60

	6	8.	6	9°	7	0°	7	1•	
'	Vers.	Ex. sec.							
0	.62539 .62566	1.66947 1.67189	.64168 .64190	1.79043 1.79254	.65798 .65825	1.92380 1.92614	.67448 .67471	2.07155 2.07415 2.07675	0 1 2
2 3 4	.62593 .62620 .62647	1.67332 1.67525 1.67718	.64218 .64245 .64272	1.79466 1.79679 1.79691	.65853 .65880 .65907	1.92849 1.93083 1.93318	.67498 .67526 .67553	2.07986 2.08197	8 4
5	.62674	1.67911	.64299	1.80104	.65935	1.93554	.67581	2.08459	5
6	.62701	1.68105	.64326	1.80818	.65962	1.93790	.67608	2.08721	6
7	.62728	1.68299	.64358	1.80531	.65989	1.94026	.67636	2.08983	7
8	.62755	1.68494	.64381	1.80746	.66017	1.94263	.67663	2.09246	8
9	.62782	1.68689	.64408	1.80960	.66044	1.94500	.67691	2.09510	9
10	.62809	1.68884	.64435	1.81175	.66071	1.94787	.67718	2.09774	10
11	.62836	1 69079	.64462	1.81390	.66099	1.94975	.67746	2.10038	11
12	.62863	1.69275	.64489	1.81605	.66126	1.95213	.67773	2.10308	12
13	.62890	1.69471	.64517	1.81821	.66154	1.95452	.67801	2.10568	13
14	.62917	1.69667	.64544	1.82037	.66181	1.95691	.67829	2.10834	14
15	.62944	1.69864	.64571	1.82254	.66208	1.95931	.67856	2.11101	15
16	.62971	1.70061	.64598	1.82471	.66236	1.96171	.67884	2.11367	16
17	.62998	1.70258	.64625	1.82688	.66263	1.96411	.67911	2.11635	17
18	.63025	1.70455	.64653	1.82906	,66290	1.96652	.67989	2.11903	18
19	.63052	1.70653	.64680	1.83124	.66318	1.96898	.67966	2.12171	19
20 21	.63079 .63106	1.70851 1.71050	.64707 .64784	1.88842 1.88561	.66345 .66373	1.97135	.67994	2.12440 2.12709	20 21
22	.63133	1.71249	.64761	1.83780	.66400	1.97619	.68049	2.12979	22
23	.63161	1.71448	.64789	1.83999	.66427	1.97862	.68077	2.13249	23
24	.63188	1.71647	.64816	1.84219	.66455	1.98106	.68104	2.13520	24
25	.63215	1.71847	.64843	1.84439	.66482	1.98349	.68182	2.18791	25
26	.63242	1.72047	.64870	1.84659	.66510	1.96594	.68159	2.14063	26
27	.63269	1.72247	.64898	1.84880	.66537	1.98838	.68187	2.14385	27
28	.63296	1.72448	.64925	1.85102	.66564	1.99083	.68214	2.14608	28
29	.63323	1.72649	.64952	1.85323	.66592	1.99829	.68242	2.14881	29
80	.63350	1.72850	.64979	1.85545	.66619	1.99574	.68270	2.15155	30
81	.63377	1.73052	.65007	1.85767	.66647	1.99821	.68297	2.15429	31
82	.63404	1.73254	.65034	1.85990	.66674	2.00067	.68325	2.15704	32
83	.63431	1.73456	.65061	1.86213	.66702	2.00815	.68352	2.15979	33
84	.63458	1.73659	.65088	1.86437	.66729	2.00562	.68380	2.16255	34
85	.63485	1.73862	.65116	1.86661	.66756	2.00810	.68408	2.16531	35
86	.63512	1.74065	.65143	1.86885	.66784	2.01059	.68435	2.16808	36
87	.63539	1.74269	.65170	1.87109	.66811	2.01308	.68468	2.17085	37
88	.63566	1.74473	.65197	1.87334	.66839	2.01557	.68490	2.17368	38
39	.63594	1.74677	.65225	1.87560	.66866	2.01807	.68518	2.17641	39
40 41	.63621 .63648	1.74881 1.75086	.65252 .65279 .65306	1.87785 1.88011 1.88238	.66994 .66921 .66949	2.02057 2.02308 2.02559	.68546 .68573 .68601	2.17920 2.18199 2.18479	40 41 42
42 43 44	.63375 .63702 .63729	1.75292 1.75497 1.75708	.65334 .65361 .65388	1.88465 1.88692	.66976 .67003	2.02810 2.03062 2.03315	.68628 .68656 .68684	2.18759 2.19040 2.19322	43 44 45
45 46 47	.63756 .63783 .63310	1.75909 1.76116 1.76328	.65416 .65443	1.89148 1.89376	.67031 .67058 .67066	2.03568 2.03821 2.04075	.68711 .68789 .68767	2.19604 2.19686 2.20169	46 47 48
48 49 50	.63338 .63333 .63332	1.76530 1.76737 1.76945	.65470 .65497 .65525	1.89605 1.89834 1.90063	.67113 .67141 .67168	2.04329 2.04584	.68794 .68822	2.20453 2.20737	49 50
51	.63919	1.77154	.65552	1.90298	.67196	2.04839	.68849	2.21021	51
52	.63946	1.77362	.65579	1.90524	.67223	2.05094	.68877	2.21306	52
53	.63973	1.77571	.65607	1.90754	.67251	2.05350	.68905	2.21592	53
54	.64000	1 77780	.65634	1.90986	.67278	2.05607	.68932	2.21878	54
55	.64027	1.77990	.65661	1.91217	.67306	2.05864	.68960	2.22165	55
56	.61055	1.78200	.65689	1.91449	.67333	2.06121	.68988	2.22452	56
57	.64032	1.78410	.65716	1.91681	.67361	2.06379	.69015	2.22740	57
58	.64109	1.78621	.65743	1.91914	.67388	2.06637	.69043	2.23028	58
59	.61136	1.78832	.65771	1.92147	.67416	2.06896	.69071	2.23317	59
60	.64163	1.79043	.65798	1.92380	.67443	2.07155	.69098	2.23607	60

	7	2°	7	'3°	7	4°	7	5°	,
	Vers.	Ex. sec.							
0	.69098 .69126	2.23607 2.23897	.70763 .70791	2.42030 2.42356	.72436 .72464	2.62796 2.68164	.74118 .74146	2.86370 2.86790	0
8	.69154 .69181	2.24187 2.24478	.70818	2.42683 2.43010	72492	2 63533 2.63903	.74174	2.87211 2.87633	8
5	.69209 .69237	2.24770	70874	2.43337	.72548 .72576	2.64274	.74281 .74259	2.88056 2.88479	5
6	69264	2.25062 2.25355	.70902 .70930	2.43666 2.43995	.72604	2.64645 2.65018	.74287	2.88904	6
8	.69292 .69320	2.25648 2.25942	.70958 .70985	2.44324 2.44655	.72632 .72660	2.65891 2.65765	.74815	2.89830 2.89756	8
9	.69347	2 26237	.71018	2.44986	.72688	2.66140	.74371	2.90184	9
10	.69375	2.26531	.71041	2.45317	.72716	2.66515	.74399	2.90618	10
11 12	.69403 .69430	2.26827 2.27123	.71069	2.45650 2.45983	.72744	2.66892 2.67269	.74427	2.91042 2.91478	11 12
18	.69458	2.27420	.71125	2.46316	.72800	2.67647	.74484	2.91904	13
14 15	.69486 .69514	2.27717 2.28015	.71158	2.46651 2.46986	.72828 .72856	2.68025 2.68405	.74512 .74540	2.92837 2.92770	14 15
16	.69541	2.28313	.71208	2.47821	.72884	2.68785	.74568	2.93204	16
17 18	.69569 .69597	2.28612 2.28912	.71236 .71264	2.47658 2.47995	.72912	2.69167 2.69549	.74596	2.93640 2.94076	17 18
19	.69624	2.29212	.71292	2.48333	.72968	2.69931	.74652	2.94514	19
20	.69652	2.29512	.71820	2.48671	.72996	2.70315	.74680	2.94952	20
21 22	.69680 .69708	2.29814 2.30115	71348	2.49010 2.49350	.73024 .73052	2.70700 2.71085	.74709	2.95392 2.95832	21 22
23	.69785	2.80418	.71403	2.49691	.73080	2.71471	.74765	2.06274	23
24 25	.69763 .69791	2.30721 2.31024	.71481	2.50032 2.50374	.73108 .73136	2.71858 2.72246	.74798	2.96716 2.97160	24 25
26	.69818	2.31328	.71487	2.50716	.73164	2.72685	.74849	2.97604	26
27 28	.69846 .69874	2.31633	.71515	2.51060	.73192	2.73024 2.73414	.74878	2.98050 2.98497	27 28
29	.69902	2.81989 2 32244	.71571	2.51404 2.51748	.73248	2.73806	.74934	2.98944	29
80	.69929	2.32551	.71598	2.52094	.73276	2.74198	.74962	2.99893	30
81 32	.69957 .69985	2.32858 2.33166	.71626 .71654	2.52440 2.52787	.73304	2.74591 2.74984	.74990 .75018	2.99848 3.00298	31 32
33	.70018	2.83474	.71682	2.53184	.73360	2.75379	.75047	8.00745	33
34 35	.70040 .70068	2.33783 2.84092	.71710 .71738	2.53482 2.53831	.73388 .73416	2.75775 2.76171	.75075 .75108	8.01198 8.01652	84 35
86	.70096	2.84403	.71766	2.54181	.73444	2.76568	.75181	8.02107	36
37 38	.70124 .70151	2.84718 2.85025	.71794 .71822	2.54531 2.54883	.73472	2.76966 2.77365	.75159 .75187	8.02568 8.03020	37 38
89	.70179	2.35336	.71850	2.55235	.73529	2.77765	.75216	8.03479	39
40	.70207	2.35649	.71877	2.55587	.73557	2.78166	.75244	3.03938	40
41 42	.70235 .70263	2.35962 2.36276	.71905	2.55940 2.56294	.73585	2.78568 2.78970	.75272 .75300	8.04398 8.04860	41
43	.70290	2.86590	.71961	2.56649	.73641	2.79374	.75328	8.05822	43
44	.70318 .70346	2.86905 2.87221	.71989 .72017	2.57005 2.57361	.73669 .73697	2.79778 2.80183	.75356 .75385	8.05786 8.06251	44
46	.70874	2.87537	.72045	2.57718	.73725	2.80589	.75418	8.06717	46
47 48	.70401 .70429	2.87854 2.88171	.72073 .72101	2.58076 2.58434	.73753 .73781	2.80996 2.81404	.75441	8.07184 8.07652	47 48
49	.70457	2.88489	.72129	2.58794	.73809	2.81818	.75497	8.08121	49
50	.70485	2.38808	.72157	2.59154	.73837	2.82223	.75526	8.08591	50
51 52	.70518 .70540	2.89128 2.89448	.72185 .72218	2.59514 2.59876	.73865 .73893	2.82633 2.83045	.75554 .75582	8.09068 8.09585	51 52
58	.70568	2.89768	.72241	2.60238	.73921	2.83457	.75610	8.10009	58
54	.70596 .70624	2.40089 2.40411	.72269 .72296	2.60601 2.60965	.78950 .78978	2.83871 2.84285	.75689	8.10484 8.10960	54 55
56	.70652	2.40784	.72324	2.61330	.74006	2.84700	.75695	8.11487	56
57 58	.70679	2.41057	.72852 .72880	2.61695	.74034	2.85116	.75723	8.11915 8.12394	57 58
59	.70707 .70785	2.41381 2.41705	.72408	2.62061 2.62428	.74062 .74090	2.85533 2.85951	.75751 .75780	8.12875	59
60	.70768	2.42030	.72436	2.62796	.74118	2.86370	.75808	8.13357	60

	7	' 6 °	7	7:	7	8.	7	9°	
	Vers.	Ex. sec.	Vers.	Ex. sec.	Vers.	Ex. sec.	Vers.	Ex. sec.	
0 1 2 3 4 5 6 7 8 9	.75808 .75836 .75836 .75864 .75862 .75921 .75949 .75977 .76005 .76034 .76002 .76090	8.13357 8.13839 8.14828 8.14809 8.15295 8.15782 8.16271 8.16761 8.17252 8.17744 8.18238	.77505 .77583 .77562 .77590 .77618 .77647 .77675 .77708 .77782 .77760	8.44541 8.45102 8.4664 8.46228 8.46798 8.47360 8.47928 8.48498 8.48498 8.49642 8.50216	.79309 .79287 .79286 .79294 .79322 .79351 .79380 .79408 .79465 .79493	3.80973 3.81638 3.82294 3.82956 3.83621 3.84288 3.84956 3.85627 3.86299 3.86973 3.87649	.80919 .80948 .80976 .81005 .81083 .81062 .81199 .81119 .81148 .81176 .81205	4.24084 4.24870 4.25658 4.26448 4.27241 4.28036 4.28833 4.29634 4.30436 4.31241 4.32049	0 1 2 8 4 5 6 7 8 9
11 12 13 14 15 16 17 18 19 20	.76118 .76147 .76175 .76208 .76231 .76260 .76288 .76316 .76344 .76373	8.19733 8.19228 3.19725 8.20224 8.20728 8.21224 8.21726 8.22229 8.22734 8.23239	.77817 .77845 .77874 .77902 .77980 .77959 .77967 .78015 .78044 .78072	8.50791 8.51868 8.51947 8.52527 8.53109 8.53892 8.54277 8.54863 8.55451 8.56041	.79522 .79550 .79579 .79607 .79696 .79664 .79698 .79721 .79750 .79778	8.88327 8.89007 8.89689 8.90878 8.91058 8.91746 8.92486 8.93128 8.93821 8.94517	.81283 .81262 .81290 .81819 .81848 .81876 .81405 .81483 .81462 .81491	4.82859 4.83671 4.84486 4.85804 4.86124 4.86947 4.87772 4.39600 4.89481 4.40263	11 12 18 14 15 16 17 18 19 20
22 22 24 25 25 25 25 25 25 25 25 25 25 25 25 25	.76401 .76429 .76458 .76486 .76514 .76542 .76571 .76599 .76627 .76655	8.28746 3.24255 3.24764 8.25275 8.25787 3.26300 3.26814 8.27330 8.27847 8.28366	.78101 .78129 .78157 .78186 .78214 .78242 .78271 .78299 .78328	8.56632 8.57224 3.57819 3.58414 8.59012 8.59611 8.60211 8.60818 8.61417 3.62028	.79807 .79835 .79864 .79892 .79921 .79949 .79978 .80006 .80035	8.95215 8.95914 8.96616 8.97320 8.96025 8.96025 8.99448 4.00155 4.00669 4.01585	.81519 .81548 .81576 .81605 .81633 .81662 .81691 .81719 .81748	4.41099 4.41987 4.42778 4.48622 4.44468 4.45817 4.46169 4.47028 4.47881 4.48740	21 22 23 24 25 26 27 28 29 20
31 32 33 34 35 36 37 38 39 40	.76684 .76712 .76740 .76769 .76797 .76825 .76854 .76882 .76910 .76938	8.28885 8.29406 8.29929 8.30452 8.30977 8.31508 8.32031 8.32560 9.33090 8.33622	.78384 .78413 .78441 .78470 .78498 .78526 .78555 .78583 .78612 .78640	8.62630 3.63238 8.63849 8.64461 8.65074 8.65690 8.66307 8.66307 8.66925 8.67545 8.68167	.80092 .80120 .80149 .80177 .80206 .80234 .80268 .80291 .80320 .80348	4.02308 4.03024 4.03746 4.04471 4.05197 4.05926 4.06657 4.07390 4.08125 4.08863	.81805 .81834 .81862 .81891 .81919 .81948 .81977 .82005 .82034 .82063	4.49608 4.50468 4.51887 4.52208 4.58081 4.53958 4.54887 4.55720 4.56605 4.57493	81 82 83 84 85 86 87 88 89 40
41 42 43 44 45 46 47 48 49 50	.76967 .76995 .77023 .77052 .77080 .77108 .77137 .77165 .77193 .77222	8.84154 8.34689 8.35224 8.85761 8.36299 8.36839 8.37380 8.37380 8.37928 8.38466 8.39012	.78669 .78697 .78725 .78754 .78782 .78811 .78839 .78868 .78896 .78924	3.68791 3.69417 3.70044 8.70673 3.71303 8.71935 8.72569 8.73205 8.73843 8.74482	.80377 .80405 .80434 .80462 .80491 .80520 .80548 .80577 .80605	4.09608 4.10844 4.11088 4.11885 4.12588 4.12588 4.14087 4.14087 4.14849 4.15599 4.16359	.82091 .82120 .82148 .82177 .82206 .82284 .82263 .82292 .82320 .82349	4.58383 4.59277 4.60174 4.61976 4.62881 4.63790 4.64701 4.65616 4.66583	41 42 43 44 45 46 47 48 49 50
51 52 53 54 55 56 57 58 59 60	.77250 .77278 .77307 .77385 .77368 .77368 .77392 .77420 .77448 .77477 .77505	8.39558 8.40106 8.40656 8.41206 8.41759 8.42812 8.42867 8.43982 8.43982 8.44541	.78953 .78981 .79010 .79088 .79067 .79095 .79128 .79152 .79180 .79209	8.75128 8.75766 3.76411 8.77057 8.77705 8.77835 8.79355 8.79007 8.79661 8.80316 8.80973	.80662 .80691 .80719 .80748 .80776 .80805 .80838 .80862 .80891	4.17121 4.17886 4.18652 4.19421 4.20193 4.20966 4.21742 4.22521 4.23901 4.24084	.82377 .82406 .82435 .82463 .82492 .82521 .82549 .82578 .82607 .82635	4.67454 4.68877 4.69304 4.70284 4.71166 4.72102 4.73041 4.73983 4.74929 4.75877	51 52 53 54 55 56 57 58 59 60

Γ		80°	8	31°		32°		33°	<u> </u>
1	Vers.	Ex. sec.	,						
0123456789	.82635 .82664 .82692 .82721 .82750 .82.778 .82807 .82836 .82844 .82898	4.75877 4.76829 4.77784 4.78742 4.79708 4.80667 4.80667 4.82606 4.83581 4.84558	.84357 .84385 .84414 .84448 .84471 .84500 .84529 .84558 .84586 .84615	5.39245 5.40422 5.41602 5.42787 5.43977 5.45171 5.46369 5.47572 5.48779 5.49991	.86083 .86112 .86140 .86169 .86129 .86227 .86256 .86284 .86313 .86343	6.18530 6.20020 6.21517 6.23019 6.24529 6.26044 6.27566 6.29095 6.30630 6.33171	.87818 .87842 .87871 .87900 .87929 .87957 .87966 .88015 .88044 .88073	7.20551 7.22500 7.24457 7.26425 7.28402 7.36388 7.3284 7.34390 7.36405 7.38431	012845678910
10 11 12 13 14 15 16 17 18 19 20	.82922 .82950 .82979 .83006 .83036 .83065 .83122 .83122 .83151 .83180 .83206	4.85589 4.86524 4.87511 4.88502 4.89497 4.90495 4.91496 4.92501 4.93509 4.94521 4.96536	.84644 .84673 .84701 .84730 .84759 .84788 .84816 .84845 .84874 .84903 .84931	5.51208 5.52429 5.53655 5.54886 5.56121 5.57361 5.58606 5.59635 5.61110 5.62369 5.63633	.86371 .86400 .86428 .86457 .86486 .86515 .86544 .86573 .86601 .86630 .86659	6.33719 6.35274 6.36835 6.38403 6.39978 6.41560 6.43148 6.44743 6.46346 6.47955 6.49571	.88102 .88181 .88160 .88188 .88217 .88246 .88275 .88304 .88333 .88362 .88391	7.40466 7.42511 7.44566 7.46632 7.48707 7.50793 7.52889 7.54996 7.57118 7.59241 7.61879	10 11 12 18 14 15 16 17 18 19 20
21 22 22 24 25 25 25 25 25 25 25 25 25 25 25 25 25	.83237 .83266 .83294 .83323 .83352 .83380 .83409 .83438 .83467 .83405	4.96555 4.97577 4.96603 4.99633 5.00666 5.01703 5.02743 5.08787 5.04834 5.05886	.84960 .84989 .85018 .85046 .85075 .85104 .85133 .85162 .85190 .85219	5.64902 5.66176 5.67454 5.68738 5.70027 5.71821 5.72620 5.738924 5.75233 5.76547	.86688 .86717 .86746 .86774 .86803 .86832 .86861 .86890 .80919 .86947	6.51194 6.52825 6.54462 6.56107 6.57759 6.59418 6.61085 6.62759 6.64441 6.66130	.88420 .88448 .88477 .88506 .88535 .88564 .88593 .88622 .88651 .88680	7.63528 7.65688 7.67859 7.70041 7.72234 7.74438 7.76653 7.78880 7.81118 7.83367	21 22 23 24 25 26 27 28 29 30
31 32 33 34 35 36 37 38 39 40	.83524 .83553 .83581 .83610 .83639 .83667 .83696 .83725 .83754 .83782	5.06941 5.08000 5.09062 5.10129 5.11199 5.12273 5.13850 5.14482 5.15517 5.16607	.85248 .85277 .85305 .85334 .85363 .85392 .85420 .85449 .85478 .85507	5.77866 5.79191 5.80521 5.81856 5.83196 5.84542 5.85893 5.87250 5.88612 5.89979	.86976 .87005 .87084 .87063 .87092 .87120 .87149 .87178 .87207 .87236	6.67826 6.69580 6.71242 6.72962 6.74689 6.76424 6.78167 6.79918 6.81677 6.83448	.88709 .88737 .88766 .88795 .88824 .88853 .88882 .88911 .88940	7.85628 7.87901 7.90186 7.92482 7.94791 7.97111 7.99444 8.01788 8.04146 8.06515	81 82 83 84 85 86 87 88 89 40
41 42 43 44 45 46 47 48 49 50	.83811 .83840 .83868 .83897 .83926 .83954 .83963 .84012 .84041 .84069	5.17700 5.18797 5.19898 5.21004 5.22118 5.23226 5.24348 5.25464 5.26590 5.27719	.85536 .85564 .85593 .85622 .85651 .83680 .85708 .85737 .85766 .85795	5.91352 5.92731 5.94115 5.95505 5.96900 5.98301 5.99708 6.01120 6.02538 6.03962	.87265 .87294 .87322 .87351 .87380 .87409 .87488 .87467 .87496	6.85218 6.87001 6.88792 6.90592 6.92400 6.94216 6.96040 6.97878 6.99714 7.01565	.88998 .89027 .89055 .89084 .89113 .89142 .89171 .89200 .89229 .89258	8.08897 8.11292 8.13699 8.16120 8.18553 8.20999 8.23459 8.25981 8.28417 8.30917	41 42 48 44 45 46 47 48 49 50
51 52 58 54 55 56 57 58 59 60	.84098 .84127 .84155 .84184 .84213 .84242 .84270 .84299 .84328 .84857	5.28858 5.29991 5.31188 5.82279 5.33429 5.34584 5.35748 5.36906 5.89078 5.39245	.85823 .85852 .85881 .85910 .85939 .85967 .85996 .86025 .86054 .86083	6.05392 6.06828 6.08269 6.09717 6.11171 6.12630 6.14096 6.15568 6.17046 6.18530	.87553 .87582 .87611 .87640 .87669 .87698 .87726 .87755 .87784 .87818	7.03428 7.05291 7.07167 7.09052 7.10946 7.12849 7.14760 7.16681 7.18612 7.20551	.89287 .89316 .89345 .89374 .89408 .89431 .89460 .89489 .89518	8.33430 8.35957 8.38497 8.41052 8.43620 8.46203 8.48800 8.51411 8.54037 8.56677	51 52 53 54 55 56 57 58

		14 °		15°	8	16°	,
	Vers.	Ex. sec.	V,ers.	Ex. sec.	Vers.	Ex. sec.	
0	.89547 .89576	8.56677 8.59888	.91284 .91318	10.47871 10.51199	.93024 .93058	13.83559 13.39547	0
2 8	.89605 .89634	8.62002 8.64687	.91842 .91371	10.55052 10.58982	.93082 .93111	18.45586 18.51676	2 8
1 4	.89668	8.67387	.91400	10.62887	.93140	18.57817	4
6	.89692 .89721	8.70108 8.72838	.91429 .91458	10.66769 10.70728	.93169 .93198	13.64011 13.70258	6
7	.89750	8.75579	.91487	10.74714	.93227	13.76558	7
8	.89779 .89808	8.78341	.91516	10.78727	.93257 .93286	18.82918 18.89328	8
10	.89636	8.81119 8.83912	.91545 .91574	10.82768 10.86837	.98315	18.95788	10
11 12	.89865 .89894	8.86722 8.89547	.91608 .91632	10.90934 10.95060	.93344	14.02310 14.08890	11 12
18	.89928	8.92389	.91661	10.99214	.93402	14.15527	13
14 15	.89952 .89981	8.95248 8.96128	.91690	11.08897	.93431	14.22228 14.28979	14 15
16	.90010	9.01015	.91719 .91748	11.07610 11.11852	.93460 .93489	14.85795	16
17	.90039	9.03923	.91777	11.16125	.93518	14.42679	17
18	.90068 .90097	9.06849 9.09792	.91806 .91835	11.20427 11.24761	.93547 .93576	14.49611 14.56614	18 19
20	.90126	9.12752	.91864	11.29125	.93605	14.63679	20
21 22	.90155 .90184	9.15730 9.18725	.91893 .91922	11.88521 11.87948	.93634	14.70810 14.78005	21 22
28	.90218	9.21789	.91951	11.42408	.93692	14.85268	28
24 25	.90242 .90271	9.24770 9.27819	.91980 .92009	11.46900 11.51424	.93721 .93750	14.92597 14.99995	24 25
26	.90300	9.80887	.92038	11.55982	.93779	15.07462	26
27 28	.90329 .90358	9.83978 9.87077	.92067 .92096	11.60572 11.65197	.93808 .93887	15.14999 15.22607	27
29	.90386	9.40201	.92125	11.69856	.93866	15.30287	29
80	.90415	9.43343	.92154	11.74550	.93895	15.88041	80 81
81 82	.90444 .90478	9.46505 9.49685	.92183 .92212	11.79278 11.84042	.93924	15.45869 15.53772	82
88	.90502	9.52886	.92241	11.88841	.93982	15.61751	83
84 85	.90531 .90560	9.56106 9.59846	.92270 .92299	11.93677 11.98549	.94011 .94040	15.69808 15.77944	84 85
86	.90589	9.62605	.92328	12.03458	.94069	15.86159	86
87	.90618 .90647	9.65885 9.69186	.92357 .92386	12.08040 12.13388	.94098	15.94456 16.02885	87 38
89	.90676	9.72507	.92115	12.18411	.94156	16.11297	89
40	.90705 .90734	9.75849 9.79212	.92444	12.23472 12.28572	.94186	16.19843 16.28476	40
42	.90768	9.82596	.92502	12.33712	.91214	16.87196	42
43	.90792 .90821	9.86001 9.89428	.92531 .92560	12.38891 12.44112	.94278	16.46005 16.54908	48
45	.90850	9.92877	.92589	12.49378	.94331	16.63893	45
46	.90879 .90908	9.96348 9.99841	.92618 .92647	12.54676 12.60021	.94360 .94389	16.72975 16.82152	46 47
48	90937	10.03356	.92676	12.65408	.94418	16.91424	48
49 50	.90966 .90995	10.06894 10.10455	.92705 .92734	12.70838 12.76312	.94447 .94476	17.00794 17.10262	49 50
51	.91024	10.14089	.92763	12.81829	.94505	17.19830	51
52 58	.91053 .91082	10.17646 10.21277	.92792	12.87391 12.92999	.94584 .94568	17.29501 17.89274	52 53
54	.91111	10.24932	.92850	12.98651	.94592	17.49158	54
53 56	.91140 .91169	10.28610 10.82318	.92979	13 04350 13.10096	.94621 .94650	17.59189 17.69283	55
57	.91197	10.86040	.92937	18.15889	.94679	17.79438	56 57
58	.91226 .91255	10.39702 10.43569	.92966 .92995	13.21730 13.27620	.94708	17.89755 18.00185	58 59
60	.91284	10.47371	.93024	13.33559	.91766	18.10788	60

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	Vers.	Ex. sec.	Vers.	Ex. sec.	Vers.	Ex. sec.	
0	.94766	18.10782	.96510	27.65871	. 98255	56.29869	0
1 2	.94795 .94825	18.21897 18.82182	.96539 .96568	27.89440 28.13917	.98284 .98318	57.26976 58.27481	2
8	.94854	18.43088	.96597	28.38812	.98342	59.81411	8
4	.94888	18.54119	.96626	28.64137	.98371	60.89105	4
5	.94912 .94941	18.65275 18.76560	.96655 .96684	28.89903 29.16120	.98400 .98429	61.50715 62.66460	5
1 7	.94970	18.87976	.96714	29.42802	.98458	68.86572	7
8	.94999	18.99524	.96748	29.69960	.98487	65.11804	8
10	.95028 .95057	19.11208 19.23028	.96772	29.97607 80.25758	.98517	66.40927 67.75786	10
11	.95098	19.24989	.96830	30.54425	.98575	69.16047	11
12	.95115	19.47093	.96859	30.83623	.98604	70.62285	12
18	.95144	19.59341	.96888	81.13366	.98633	72.14588	18
14	.95178 .95202	19.71737	.96917	81.43671 81.74554	.98662	73.73586 75.39655	14 15
16	.95231	19.84288 19.96982	.96946	81.74554 82.06030	.98691 .98720	77.13274	16
17	.95260	20.09838	.97004	32.38118	.98749	78.94968	17
18	.95289	20.22852	.97033	82.70835	.98778	80.85815	18 19
19 20	.95318 .95847	20.86027 20.49368	.97062	33.04199 33.38232	.98807	82.84947 84.94561	20
21	.95877	20.62876	.97121	33.72952	.98866	87.14924	21
22	.95406	20.76555	.97150	84.08380	.98895	89.46886	22
23	.95435 .95464	20.90403 21.04440	.97179	84.44539 84.81452	.98924	91.91887 94.49471	23 24
25	.95493	21.18653	97208	85.19141	.98982	97.22303	25
26	.95522	21.83050	.97266	85.57688	.99011	100.1119	26
27	.95551	21.47635	.97295	85.96953	.99040	108.1757	27 28
29	.95580 .95609	21.62413 21.77386	.97324 .97358	86.87127 86.78185	.99069	106.4311 109.8966	29
89	.95638	21.92559	.97382	87.20155	.99127	118.5980	80
81	.95667	22.07935	.97411	87.63068	.09156	117.5444	81
82	.95696 .95725	22.23520 22.39316	.97440 .97470	38.06957 38.51855	.99186	121.7780 126.8258	32 33
84	.95754	22.55829	.97499	38.97797	.99244	181.2223	34
85	.95788	22.71568	.97528	89.44820	.99278	186.5111	85
86 87	.95812 .95842	22.88022 23.04712	.97557 .97586	39.92963 40.42266	.99302	142.2406 148.4684	36 37
88	95871	28.21687	.97615	40.92772	.99860	155 9698	38
89	.95900	23.88802	.97644	41.44525	.99389	162.7088	39
40	.95929	23.56212	.97673	41.97571	.99418	170.8883	40
41 42	.95958 .95987	23.73873 23.91790	.97702	42.51961 43.07746	.99447	179.9350 189.9868	41
43	.96016	24.09969	.97760	48.64980	.99505	201.2212	43
44	.96045	24,28414	.97789	44.23720	.99585	213.8600	44
45	.96074 .96108	24.47184 24.66182	.97819	44.84026 45.45968	.99564	228.1839 244.5540	45 46
47	.96182	24.85417	.97877	46.09596	.99622	263.4427	47
48	.96161	25.04994	.97906	46.74997	.99651	285.4795	48
49 50	.96190 .96219	25.24869 25.45051	.97935 .97964	47.42241 48.11406	.99680	811.5280 842.7752	49 50
51	.96248	25.65546	.97998	48.82576	.99788	880.9728	51
52	.96277	25.86360	.98022	49.55840	.99767	428.7187	52
58	.96307	26.07503	.98051	50.81290	.99798	490.1070	58
54	.96336 .96365	26.28981 26.50804	.98080 .98109	51.09027 51.89156	.99825	571.9581 686.5496	54 55
56	.96394	26.72978	.98138	52.71790	.99884	858.4869	56
57	.96428	26.95518	.98168	53.57046	.99918	1144.916	57
58	.96452 .96481	27.18417 27.41700	.98197	54.45053 55.85946	.99942	1717.874 8486.747	58 59
1 80	.96510	27.65871	.98255	56.29869	1.00000	Infinite	60

TABLE V.—SQUARES, CUBES, SQUARE ROOTS,

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
1 2 3 4 5 6 7	1 4 9 16 25 86 49 64 81	1 8 27 64 125 216 843 513 729	1.0000000 1.4142186 1.7320508 2.0000000 2.2360680 2.4494897 2.6457518 2.8284271 3.0000000	1.0000000 1.2599210 1.4422496 1.5874011 1.7099759 1.8171206 1.9129312 2.0000000 2.0800837	1.00000000 .50000000 .83333333 .25000000 .20000000 .166666667 .142857148 .12500000
10 11 12 13 14 15 16 17 18	100 121 144 169 196 225 256 289 824 361	1000 1831 1788 2197 2744 8875 4096 4913 5832 6859	8.16824777 8.8166248 8.4641016 8.6055513 8.7416674 8.8729833 4.000000 4.1281056 4.2486407 4.3558989	2.1544347 2.2289901 2.2894286 2.3518847 2.4101423 2.4662121 2.5196421 2.5712816 2.6207414 2.66844016	.10000000 .090909091 .08333333 .076922077 .071428571 .066666667 .082500000 .058823529 .056565656
20 21 22 23 24 25 26 27 28 29	400 441 484 529 576 625 676 729 784 841	8000 9261 10648 12167 18824 15625 17576 19683 21952 24889	4.4721360 4.5825757 4.6904158 4.7958315 4.8989795 5.0000000 5.0990195 5.1961524 5.2915026 5.3851648	2. 7144177 2. 7589243 2. 8020893 2. 8438670 2. 8844991 2. 9240177 2. 9624960 3. 0000000 3. 0965889 3. 0722168	,05000000 .047619048 .045454545 .043478261 .041666667 .04000000 .088461538 .037087087 .035714286 .034482759
80 81 82 83 84 85 86 87 88	900 961 1024 1089 1156 1225 1296 1369 1444 1521	27000 29791 82768 85937 859304 42275 46656 50653 54872 59919	5.4772256 5.5677644 5.6568542 5.7445626 5.8309519 5.9160798 6.000000 6.0827625 6.16444980	8.1072325 8.1413906 8.1748021 8.2075343 8.2396118 8.2710663 8.8019272 8.3322218 8.3619754 8.3912114	.088888888 .082258065 .081250000 .080690300 .029411765 .028571429 .027777778 .027027027 .026315789 .02541026
40 41 42 43 44 45 46 47 48 49	1600 1681 1764 1849 1936 2025 2116 2209 2304 2401	64000 68921 74088 79507 85184 91125 97336 103823 110592 117649	6.3245558 6.4031242 6.4807407 6.5574385 6.6332496 6.7082039 6.7823300 6.8556546 6.9282032 7.0000000	3, 4199519 3, 4482172 3, 4760266 3, 5083981 3, 5308483 3, 5880479 3, 6088261 3, 6342411 3, 6589057	02500000 024390244 023809534 02255514 022727273 022222222 021739130 021276600 020838383 020406163
50 51 52 58 54 55 56 57 58	2500 2601 2704 2809 2916 8025 8136 8249 8364	125000 132651 140608 148877 157464 166375 175616 185198 195112	7.0710678 7.1414284 7.2111026 7.2901099 7.3484692 7.4161965 7.4833148 7.5498344 7.6167731	3.6840314 3.7064298 3.7325111 3.7562858 3.7797631 3.8029525 3.8258624 3.8485011 3.8706766	.02000000 .019607848 .019280769 .018867925 .018518519 .018181818 .017857148 .017542860 .017241379
59 60 61 62	8481 8600 8721 8844	205379 216000 226981 238328	7.6811457 7.7459667 7.8102497 7.8740079	8.8929965 8.9148676 8.9364978 8.9578915	.016949158 .016666667 .016393448 .016129082

CUBE ROOTS, AND RECIPROCALS.

				1	
No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
63	8969	250047	7.9372589	8.9790571	.015873016
64	4096	262144	8.0000000	4.0000000	.015625000
65	4225	274625	8.0622577	4.0207256	.015384615
66	4356	287496	8.1240384	4.0412401	.015151515
67 68	4489 4624	800763 814432	8.1853528 8.2462113	4.0615480 4.0816551	.014925373 .014705882
69	4761	828509	8.3066239	4.1015661	.014492754
70	4900	843000	8.3666003	4.1212853	.014285714
71	5041	857911	8.4261498	4.1408178	.014084507
72	5184	873248 889017	8.4852814 8.5440037	4.1601676 4.1798890	.013888889 .013698630
78 74	5329 5476	405224	8.6023253	4.1983864	.013513514
75	5625	421875	8.6602540	4.2171633	.013333333
76	5776	488976	8.7177979	4.2358236	.013157895
77	5929	456538	8.7749644	4.2543210	.012587018
78	6084	474552	8.8317609	4.2726586	.012820513
79	6241	493039	8.8881944	4.2908404	.012658228
80	6400 6561	512000 531441	8.9442719 9.0000000	4.3088695 4.8267487	.012500000
81 82	6724	551368	9.0553851	4.8444815	.012195122
88	6889	571787	9.1104336	4.8620707	.612048198
84	7056	592704	9.1651514	4.8795191	.011904762
85	7225	614125	9.2195445	4.8968296	.011764706
86	7396	636056	9.2736185	4.4140049	.011627907
87	7569	658508	9.8278791	4.4310476	.011494253
88 89	7744 7921	681472 704969	9.3808315 9.4339811	4.4479602	.011363636 .011235955
90	8100	729000	9.4868880	4.4814047	.011111111
91	8281	758571	9.5393920	4.4979414	.010989011
92	8464	778688	9.5916630	4.5143574	.010869565
93	8649	804357	9.6436508	4.5306549	.010752688
94	8836	830584	9.6953597	4.5468359	.010638298
95 96	9025 9216	857375 884736	9.7467948 9.7979590	4.5629026 4.5788570	.010526316 .010416667
97	9409	912673	9.8488578	4.5947009	010309278
98	9604	941192	9.8994949	4.6104863	.010204082
99	9801	970299	9.9498744	4.6260650	.010101010
100	10000	1000000	10.0000000	4.6415888	.010000000
101	10201	1030301	10.0498756	4.6570095	.009900990
102 103	10404 10609	1061208 1092727	10.0995049 10.1488916	4.6723287 4.6875482	.009803922
104	10816	1124864	10.1980390	4.7026694	.009615885
105	11025	1157625	10.2469508	4.7176940	.009523810
106	11236	1191016	10.2956301	4.7326235	.009433962
107	11449	1225048	10.3440804	4.7474594	.009345794
108 109	11664 11881	1259712 1295029	10.3923048 10.4403065	4.7622032 4.7768562	.003259259
110	12100	1331000	10.4880885	4.7914199	.009090909
111	12321	1867631	10.5356588	4.8058955	.009009009
112	12544	1404928	10.5830052	4.8202845	.0089285.1
118	12769	1442897	10.6801458	4.8345881	.008849558
114	12996	1481544	10.0770788	4.8488076	.008771930
115	13225	1520875	10.7238058	4.8629442	.008695652
116	18456	1560696	10.7703296	4.8769990	.008620690
117 118	13689 18924	1601613 1643032	10.8166588 10.8627805	4.8909732 4.9048681	.008547009
119	14161	1685159	10.9087121	4.9186847	.008408361
120	14400	1728000	10.9544512	4.9324242	.0088333333
121	14641	1771561	11.00,0000	4.9460874	.008264463
122	14884	1815848	11.0453610	4.9596757	.008196721
128	15129	1860867	11.0905865	4.9731898	.008180081
124	15876	1906624	11.1355287	4.9866810	.008064516

TABLE V.-SQUARES, CUBES, SQUARE ROOTS,

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
125	15625	1953125	11.1808899	5,0000000	.008000000
126	15876	2000376	11.2249722	5.0132979	.007936508
127	16129	2048383	11.2694277	5.0265257	.007874016
128	16384	2097152	11.3137085	5.0396842	.007812500
129	16641	2146689	11.8578167	5.0527748	.007751938
130	16900	2197000	11.4017548	5.0657970	.007692808
131	17161	2248091	11.4455231	5.0787531	.007633588
132	17494	2299968	11.4891258	5.0916484	.007575758
138	17689	2352637	11.5325626	5.1044687	.007518797
134 135	17956 18225	2406104 2460375	11.5758369 11.6189500	5.1172299 5.1299278	.007462687
136	18496	2515456	11.6619038	5.1299278 5.1425682	.007352941
137	18769	2571353	11.7046999	5.1551367	.007299270
138	19044	2628072	11.7473401	5.1676498	.007246377
139	19321	2685619	11.7898261	5.1801015	.007194245
140	19600	2744000	11.8321596	5.1924941	.007142857
141	19881	28 03221	11.8743421	5.2048279	.007092199
142	20164	2863288	11.9163753	5.2171084	.007042254
148	20449	2924207	11.9582607	5.2293215	.006993007
144	20736	2985984	12.0000000	5.2414828	.006944444
145 146	21025	8048625	12.0415946	5.2535879	.006896552
140 147	21316 21609	8112186 8176528	12.0830460 12.1243557	5.2656874 5.2776321	.006849815
148	21904	8241792	12.1655251	5.2895725	.006802721
149	22201	8307949	12.2065556	5.8014592	.006711409
150	22500	8375000	12.2474487	5.3132928	.006666667
151	22801	8442951	12.2882057	5.3250740	.006622517
152	23104	8 511808	12.3288280	5.8368033	.006578947
153	23409	8581577	12,3693169	5.3484812	.006535948
154	23716	8652264	12.4096786	5.3601084	.006493506
155 156	24025 24336	8723875 8796416	12.4498996	5.3716854	.006451613
157	24649	8869893	12.4899960 12.5299641	5.3832126 5.3946907	.006410256
158	24964	8944312	12.5698051	5.4061202	.006329114
159	25281	4019679	12.6095202	5.4175015	.006289308
160	25600	4096000	12.6491106	5.4288352	.006250000
161	25921	4173281	12.6885775	5.4401218	.006211180
162	26244	4251528	12.7279221	5.4513618	.006172840
163	26569	4330747	12.7671453	5.4625556	.006184969
164	26896	4410944	12.8062485	5.4737037	.006097561
165 166	27225 27556	4492125 4574296	12.8452326	5.4848068	.006060606
167	27889	4657463	12.8840987 12.9228480	5.4958647 5.5068784	.006024096
168	28224	4741632	12.9614814	5.5178484	.005952381
169	28561	4826809	13.0000000	5.5287748	.005917160
170	28900	4913000	13.0394048	5.5396583	.005882853
171	29241	5000211	13,0766968	5.5504991	.005847958
172	29584	5088448	13.1148770	5.5612978	.005813953
178	29929	5177717	13.1529464	5.5720546	.005780347
174	80276	5268024	13.1909060	5.5827702	.005747126
175 176	80625 80976	5359375	18.2287566	5.5934447	.005714286
177	81329	5451776 5545233	13.2664992 13.3041347	5.6040787 5.6146724	.005681818
178	81684	5639752	18.3416641	5.6252263	.005617978
179	82041	5735339	13.3790882	5.6357408	.005586592
180	82400	5832000	18.4164079	5.6462162	.00555556
181	82761	5929741	13.4536240	5.6566528	.005524862
182	83124	6028568	13.4907876	5.6670511	.005494505
188	83489	6128487	13.5277493	5 6774114	.005464481
184 185	83856 84225	6229504 6331625	13.5646600	5.6877840	.005434788
186 186	34596	6434856	18.6014705	5.6980192	.005405405
100	1 04050 (0404000	13.6681817	5.7082675	.005376344

CUBE ROOTS, AND RECIPROCALS.

-						
	No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
	187	84969	6589208	13.6747948	5.7184791	.005847594
	188	85844	6644672	13.7118092	5.7286548	.005819149
	189	85721	6751269	13.7477271	5.7387986	.005291005
	190	86100	6959000	13.7840488	5.7488971	.005263158
	191	86481	6967871	13.8202750	5.7589652	.005285602
	192	86864	7077888	13.8564065	5.7689982	.005208833
	198	87249	7189057	13.8924440	5.7789966	.005181847
	194	87686	7301384	18.9288888	5.7869604	.005154689
	195	38025	7414875	18.9642400	5.7968900	.005128205
	196	88416	7529586	14.0000000	5.8067857	.005102041
	197	88809	7645878	14.0856688	5.8186479	.005076142
	198	89204	7762898	14.0712478	5.8284767	.005050505
	199	89601	7880599	14.1067860	5.8382725	.005025126
	200	40000	8000000	14.1421856	5.8480855	.005000000
	201	40401	8120601	14.1774469	5.8577660	.004975124
	202	40804	8242408	14.2126704	5.6674643	.004950495
	208	41209	8365427	14.2478068	5.8771807	.004926108
	204	41616	8489664	14.2828569	5.8667653	.004901961
	205	42025	8615125	14.3178211	5.6963685	.004878049
	206	42436	8741816	14.3527001	5.9059406	.004854869
	207	42849	8869743	14.3874946	5.9154817	.004880918
	208	43264	8998912	14.4222051	5.9249921	.004807692
	209	43681	9129829	14.4568828	5.9344721	.004784689
	210	44100	9261000	14.4918767	5.9489220	.004761905
	211 212 218 214 215	44521 44944 45369 45796 46225	9398981 9528128 9663597 9600344 9988875	14.5258890 14.5602198 14.5945195 14.6287888 14.6628788	5.9538418 5.9627820 5.9720926 5.9814240 5.9907264	.004789886 .004716981 .004694886 .004672897
	216	46656	10077696	14.6969385	6.000000	.004629680
	217	47089	10218818	14.7309199	6.0092450	.004608295
	218	47524	10360283	14.7648231	6.0184617	.004587156
	219	47961	10508459	14.7986486	6.0276502	.004566210
	220	48400	10648000	14.8323970	6.0868107	.004545455
	221	48841	10798861	14.8660687	6.0459485	.004524887
	222	49284	10941048	14.8996644	6.0550489	.004504505
	228	49729	11089567	14.9831845	6.0641270	.004484806
	224 225 226 227 228	50176 50625 51076 51529 51984	11239424 11390625 11543176 11697063 11852852	14.9666295 15.000000 15.0332964 15.0665192 15.0996689	6.0781779 6.0822020 6.0911994 6.1001702 6.1091147	.004464286 .004444444 .004424779 .004405286
	229	52441	12008989	15.1327460	6.1180882	.004866812
	230	52900	12167000	15.1657509	6.1269257	.004847826
	231	53361	12326391	15.1966849	6.1357924	.004829004
	232	53824	12487168	15.2315462	6.1446887	.004810845
	233	54289	12649387	15.2643375	6.1584495	.004291845
	234	54756	12812904	15.2970585	6.1622401	.004278504
	285	55225	12977875	15.3297097	6.1710058	.004255319
	236	55696	18144256	15.3622915	6.1797466	.004297288
	237	56169	18812058	15.3948043	6.1884628	.004219409
	238	56644	18481272	15.4272486	6.1971544	.004201681
	239	57121	18651919	15.4596248	6.2058218	.004184100
	240	57600	18824000	15.4919884	6.2144650	.004166687
	241	58061	18997521	15.5941747	6.2230848	.004149878
	242	58564	14172488	15.5568498	6.2316797	.004182281
	243	59049	14848907	15.5884578	6.2402515	.004115226
	244	59536	14526784	15.6204994	6.2487998	.004096861
	245	60025	14706125	15.6524758	6.2573248	.004081688
	246	60516	14886986	15.6843871	6.2658266	.004065041
	247	61009	15069228	15.7162336	6.2743054	.004048588
	248	61504	15252992	15.7480157	6.2827618	.004082258

TABLE V.—SQUARES, CUBES, SQUARE ROOTS,

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals
249	62001	15488249	15.7797338	6.2911946	.004016064
250	62500	15625000	15.8113883	6.2996053	.004000000
251	63001	15813251	15.8429795	6.8079935	.003984064
252	63504	16003008	15.8745079	6.3163596	.003968254
253	64009	16194277	15.9059737	6.3247035	.003952569
254 255	64516 65025	16387064 16581375	15.9373773 15.9687194	6.3330256 6.3413257	.003937008
256	65536	16777216	16.0000000	6.3496042	.003921309
257	66049	16974593	16.0312195	6.3578611	.003891051
258	66364	17173512	16.0623784	6.3660968	.003875969
259	67061	17373979	16.0934769	6.3743111	.003861004
260	67600	17576000	16.1245155	6.3825043	.003846154
261 262	68121 68644	17779581 17984728	16.1554944 16.1864141	6.3906765 6.3988279	.003831418 .003816794
263	69169	18191447	16.2172747	6.4069585	.003802281
264	69696	18399744	16.2480768	6.4150687	.003787879
265	70225	18609625	16.2788206	6.4231588	.003778585
266	70756	18821096	16.3095064	6.4812276	.003759398
267	71289	19034163	16.3401346	6.4392767	.003745318
268 269	71824 72361	19248832 19465109	16.3707055 16.4012195	6.4473057 6.4553148	.003731343
270	72900	19683000	16.4316767	6.4633041	.003703704
271	73441	19902511	16.4620776	6.4712736	.003690037
272	73984	20123648	16.4924225	6.4792236	.003676471
278	74523	20346417	16.5227116	6.4871541	.003663004
274	75076	20570824	16.5529454	6.4950653	.003649685
275	75625 76176	20796875 21024576	16.5831240 16.6132477	6.5029572 6.5108300	.003636364
276 277	76729	21253933	16.6433170	6.5186839	.003610108
278	77284	21484952	16.6733320	6.5265189	003597122
279	77841	21717639	16.7032931	6.5843351	.003584229
280	78400	21952000	16.7332005	6.5421326	.003571429
281 282	78961 79524	22188041 22425768	16.7630546 16.7928556	6.5499116 6.5576722	.003558719
283	80089	22665187	16.8226038	6.5654144	.003533569
284	8065 6	22906304	16.8522995	6.5781885	.003521127
285	81225	23149125	16.8819430	6.5808443	.003508772
286	81796	23393656	16.9115345	6.5885828	.003496503
287	82369	23639903	16.9410743	6.5962023	.003484821
288 289	82944 83521	23887872 24137569	16.9705627 17.0000000	6.6038545 6.6114890	.003472222
290	84100	24389000	17.0293864	6.6191060	.003448276
291	84681	24642171	17.0587221	6.6267054	.003436426
292	85264	24897088	17.0880075	6.6342874	.003424658
293	85849	25153757	17.1172428	6.6418522	.003412969
294	86436	25412184	17.1464282	6.6493998	.003401361
295 296	8702 5	2567237 5 2593433 6	17.1755640	6.6569302	.003389831
297	8761 6 8820 9	26198073	17.2046505 17.2336879	6.6644487 6.6719403	.003378378
298	88804	26463592	17.2626765	6.6794200	.003355705
299	89401	26730899	17.2916165	6.6868881	.003344482
800	90000	27000000	17.3205081	6.6943295	.003333333
801	90601	27270901	17.3493516	6.7017598	.003322259
302 303	91204	27543608 97818197	17.3781472 17.4068952	6.7091729	.003311258
804	91809 92416	27818127 28094464	17.405952	6.7165700 6.7289508	.003300330 .003289474
805	93025	28872625	17.4642492	6.7313155	.003278689
806	93636	28652616	17.4928557	6.7386641	.003267974
807	94249	28934443	17.5214155	6.7459967	.003257329
308	94864	29218112	17.5499288	6.7583184	.003246753
809 810	95481 96100	29503629	17.5783958	6.7606143	.003236246
OIU	80100	29791000	17.6068169	6.7678995	.003225806

CUBE ROOTS, AND RECIPROCALS.

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocale
811	96721	80080281	17.6351921	6.7751690	.003215484
812	97844	80371828	17.6685217	6.7824229	.003205128
818	97969	30664297	17.6918060	6.7896613	.003194888
814	98596	80959144	17.7200451	6.7968844	.003184713
815	99225	31255875	17.7482393	6.8040921	.003174608
816	99856	81554496	17.7763888	6.8112847	.003164557
817	100489	31855013	17.8044938	6.8184620	.008154574
818	101124	32157432	17.8325545	6.8256242	.003144654
819	101761	82461759	17.8605711	6.8327714	.003134796
820 821	102400 103041	82768000	17.8885438	6.8399087	.008125000
322 322	103684	33076161 33386248	17.9164729 17.9443584	6.8470213 6.8541240	.003115265
823	104329	83698267	17.9722008	6.8612120	.003105590
824	104976	84012224	18.0090000	6.8682855	.003095975
825	105625	34328125	18.0277564	6.8753443	
326	106276	84645976	18.0554701	6.8823888	.003076923
827	106929	84965788	18.0831413	6.8894188	.003058104
828	107584	85287552	18.1107708	6.8964845	.003048780
829	108241	85611289	18.1383571	6.9034359	.003039514
830	108900	85987000	18.1659021	6.9104232	.003030308
331	109561	86264691	18.1934054	6.9173964	.003021148
332	110224	36594368	18.2208672	6.9243556	.003012048
833	110889	36926037	18.2482876	6.9313008	.003003009
884	111556	37259704	18.2756669	6.9382321	.002994012
885	112225	87595375	18.3030052	6.9451496	.002985075
336	112896	87988056	18.3303028	6.9520533	.002976190
337	118569	88272753	18.8575598	6.9589434	.002967859
338 339	114244 114921	38614472 38958219	18.3847763 18.4119526	6.9658198 6.9726826	.002958580
840	115600	89304000	18.4390889	6.9795821	.002949858
841	116281	89651821	18.4661853	6.9863681	.002932551
842	116964	40001688	18.4932420	6.9931906	.002923977
848	117649	40353607	18.5202592	7.0000000	.002915452
844	118336	40707584	18.5472370	7.0067962	.002906977
845	119025	41063625	18.5741756	7 0135791	.002898551
846	119716	41421736	18.6010752	7.0203490	.002890173
847	120409	41781923	18.6279360	7.0271058	.002881844
848	121104	42144192	18.6547581	7.0338497	.002873568
849	121801	42508549	18.6815417	7.0405806	.002865880
850	122500	42875000	18.7082869	7.0472987	.002857148
851	123201	43243551	18.7349940	7.0540041	.002849008
352	123904	43614208	18.7616630	7.0606967	.002840909
858	124609	43986977	18.7882942	7.0673767	.002832861
854	125316	44361864	18.8148877	7.0740440	.002824859
855	126025	44738875	18.8414437	7.0806988	.002816901
856	126736	45118016	18.8679628	7.0873411	.002808989
857 858	127449 128164	45499293	18.8944436	7.0939709	.002801120
859	128881	45882712 46268279	18.9208879 18.9472958	7.1005885 7.1071987	.002793296
860	129600	46656000	18.9736660	7.1137866	.002777778
861	130321	47045881	19.0000000	7.1203674	.002770088
862	131044	47487928	19.0262976	7.1269360	.002762481
868	131769	47882147	19.0525589	7.1334925	.002754821
864	182496	48228544	19.0787840	7.1400370	.002747258
865	183225	48627125	19.1049732	7.1465695	.002739726
366	133956	49027896	19.1311265	7.1530901	.002732240
867	134689	49430868	19.1572441	7.1595988	.002724796
368	135424	49836032	19.1833261	7.1660957	.002717391
869	136161	50243409	19.2093727	7.1725809	.002710027
000					
870 871	136900 137641	50653000 51064811	19.2353841 19.2613608	7.1790544 7.1855162	.002702708 .002695418

Table V.—Squares, Cubes, Square Roots,

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
878	189129	51895117	19.8182079	7.1984050	.002680965
874	189876	52818624	19.8890796	7.2048822	.002678797
875	140625 141876	52784375 58157876	19.8649167 19.8907194	7.2112479 7.2176522	.002666667
876 877	142129	53582633	19.4164878	7.2240450	.002652520
878	142884	54010152	19.4422221	7.2304268	.002645508
879	143641	54439989	19.4679228	7.2367972	.002638522
880 881	144400 145161	54872000 55306341	19.4935887 19.5192213	7.2431565 7.2495045	.002631579 .002624672
382	145924	55742968	19.5448208	7.2558415	.002617801
888	146689	56181887	19.5703858	7.2621675	.002610966
884	147456	56623104	19.5959179	7.2684824	.002604167
885	148225	57066625	19.6214169	7.2747864	.002597403
386	148996	5 751245 6	19.6468827	7.2810794	.002590674
387	149769	57960608	19.6723156	7.2878617	.002583979
888 889	150544 151821	58411072 58863869	19.6977156 19.7230829	7.2986330 7.2998986	.002577320
390	152100	59319000	19.7484177	7.3061436	.002564108
891	152881	59776471	19.7787199	7.3123828	.002557545
892	153664	60236288	19.7989899	7.3186114 7.3248295	.002551020
898 894	154449 155236	60698457 61162984	19.8242276 19.8494832	7.3310369	.002538071
895	156025	61629875	19.8746069	7.3372339	.002531646
896	156816	62099136	19.8997487	7.8484205	.002525258
397	157609	62570773	19.9248588	7.3495966	.002518892
898	158404	63044792	19.9499378	7.3557624	.002512563
899	159201	63521199	19.9749844	7.3619178	.002506266
400	160000 160801	64000000 64481201	20.0000000	7.8680630 7.3741979	.002500000
401 402	161604	64964808	20.0249844 20.0499377	7.3808227	.002487562
403	162409	65450827	20.0748599	7.3864373	.002481390
404	163216	65939264	20.0997512	7,3925418	.002475248
405	164025	66430125	20.1246118	7.3986363	.002469136
406	164886	66928416	20.1494417	7.4047206	.002463054
407	165649	67419143	20.1742410	7.4107950	.002457002
408 409	166464 167281	67917312 68417929	20.1990099 20.2287484	7.4168595 7.4229142	.002450980
410	168100	68921000	20.2484567	7.4289589	.002439024
411	168921	69426531	20.2731349	7.4349938	.002483090
412	169744	69934528	20.2977881	7.4410189	.002427184
418 414	170569 171896	70444997 70957944	20.3224014 20.8469899	7.4470842 7.4580399	.002421308
415	172225	71473375	20.3405655	7.4590859	.002409639
416	173056	71991296	20.8960781	7.4650223	.002403846
417	173889	72511713	20.4205779	7.4709991	.002398082
418	174724 175561	73034632 73560059	20.4450483 20.4694895	7.4769664 7.4829242	.002392344
419 420	176400	74088000		7.4888724	.002380952
421	177241	74618461	20.4939015 20.5182845	7.4948118	.002375297
422	178084	75151448	20.5426386	7.5007406	.002369668
423	178929	75686967	20.5669638	7.5066607	.002364066
424	179776	8225024	20 5912603	7.5125715	.002358491
425	180625	76765625	20.6155281	7.5184780	.002352941
426 427	181476 182329	77308776	20.6397674	7.5243652	.002847418
427 428	183184	77854483 78402752	20.6639783 20.6881609	7.5302482 7.5361221	.002341920
429	184041	78953589	20.0001009	7.5419867	.002381002
430	184900	79507000	20.7364414	7.5478428	.002325581
431	185761	80062991	20.7605395	7.5536888	.002320186
432 433	186624 187489	80621568 81182737	20.7846097 20.8086520	7.5595268	.002314815
400	10/400	0110%(0(,	20.000002U	7.5653548	

CUBE ROOTS, AND RECIPROCALS.

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
435	189225	82812875	20.8566536	7.5769849	.002298851
436	190096	82881856	20.8806130	7.5827865	.002298578
487	190969	83453453	20.9045450	7.5885798	.002288330
438	191844	84027672	20.9284495 20.9523268	7.5943633	.002283105
439	192721	84604519	1	7.6001885	.002277904
440	198600	85184000	20.9761770 21.0000000	7.6059049 7.6116626	.002272727
441	194481	85766121	21.0237960	7.6174116	.002262443
442	195364	86350888 86988307	21.0475652	7.6231519	.002257336
443 444	196249 197136	87528384	21.0718075	7.6288837	.002252252
445	198025	88121125	21.0950231	7.6346067	.002247191
446	198916	88716536	21.1187121	7.6403213	.002242152
447	199809	89314623	21.1423745	7.6460272	.002237136
448	200704	89915392	21.1660105	7.6517247	.002232143
449	201601	90518849	21.1896201	7.6574188	.002227171
450	202500	91125000	21.2132034 21.2367606	7.6630943	.002222222
451	203401	91733851	21.2367606	7.6687665	.002217295
452	204304	92345408	21.2602916	7.6744303	.002212389
453	205209	92959677	21.2837967	7.5800857	.002207506
454	206116	93576664	21.3072758	7.6857328	.002202643
455	207025	94196375	21.3307290 21.3541565	7.6918717 7.6970023	.002197802 .002192982
456 457	207936 208849	94818816 95443993	21.8775583	7.7026246	.002188184
458	209764	96071912	21.4009346	7.7082388	.002183406
459	210681	96702579	21.4242853	7.7138448	.002178649
460	211600	97336000	21,4476106	7.7194426	.002173913
461	212521	97972181	21.4709106	7.7250325	.002169197
462	213444	98611128	21.4941853	7.7306141	.002164502
463	214369	99252847	21.5174348	7.7361877	.002159827
464	215296	99897344	21.5406592	7.7417532	.002155172
465	216225	100544625	21.5638587	7.7478109	.002150538
466	217156	101194696	21.5870331 21.6101828	7.7528606 7.7584023	.002145923 .002141328
467 468	218089 219024	101847563 102503232	21.6333077	7.7639361	.002136752
469	219961	103161709	21.6564078	7.7694620	.002132196
470	220900	103823000	21.6794834	7,7749801	.002127660
471	221841	104487111	21.7025344	7.7804904	.002123142
472	222784	105154048	21.7255610	7.7859928	.002118644
473	223729	105823817	21.7485632	7.7914875	.002114165
474	224676	106496424	21.7715411	7.7969745	.002109705
475	225625	107171875	21.7944947	7.8024538	.002105263
476	226576	107850176 108531333	21.8174242 21.8403297	7.8079254 7.8133892	.002100840 .002096436
477 478	227529 228484	109215352	21.8403297	7.8188456	.002092050
479	229441	109902239	21.8860686	7.8242942	.002087683
480	230400	110592000	21.9089023	7.8297353	.002086333
481	231361	111284641	21.9317122	7.8351688	.002079002
482	232324	111980168	21.9544984	7.8405949	.002074689
483	233289	112678587	21.9772610	7.8460134	.002070393
484	234256	118879904	22.0000000	7.8514244	.002066116
485	235225	114084125	22.0227155	7.8568281 7.8622242	.002061856 .002057613
486 487	236196 237169	114791256 115501303	22.0454077 22.0680765	7.8622242 7.8676130	.002058388
488	238144	116214272	22.0907220	7.8729944	.002049180
489	239121	116930169	22.1133444	7 8783684	.002044990
490	240100	117649000	22.1359436	7.8837352	.002040816
491	241081	118370771	22.1585198	7.8890946	.002036660
492	242064	119095488	22.1810730	7.8944468	.002032520
493	243049	119823157	22.2036033	7.8997917	.002028398
494	244086	120558784	22.2261108	7.9051294	.002024291
495	245025 246016	121287875 122023936	22.2485955 22.2710575	7.9104599 7.9157832	.002020202 .002016129
496	240010	1 LEAUAUSUU	1 86.6110010	1.0101006	1 .002010123

TABLE V.—SQUARES, CUBES, SQUARE ROOTS,

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
497	247009	122768478	22,2984968	7.9210994	.002012072
498 499	248004 249001	123505992 124251499	22.3159136 22.3383079	7.9264085 7.9317104	.002006032
500	250000	125000000	22.3606798	7.9370058	.002000000
501	251001	125751501	22.3830293	7.9122981	.001996008
502 508	252.304 253009	126506008 127263527	22.4053565 22.4276615	7.9475789 7.9528477	.001992032
504 504	254016	128024064	22.4499448	7.9581144	.001984127
505	255025	128787625	22.4722051	7.9633743	.001980198
506 507	256036 257049	129554216 130923843	22.4944438 22.5166605	7.9686271 7.9738731	.001976285
508	258064	131096512	22.5388553	7.9791122	.001968504
509	259081	131872229	22.5610283	7.9848444	.001964687
510	260100	182651000	22.5831796	7.9895697	.001960784
511 512	261121 262144	183432831 134217728	22.6053091 22.6274170	7.9947883 8.000000	.001956947 .001953125
513	263169	135005697	22.6495038	8.0052049	.001949318
514	264196	135796744	22.6715681	8.0104032	.001945525
515 516	265225 266256	136590875 137389096	22.6936114 22.7156334	8.0155946 8.0207794	.001941748 .001937984
517	267289	188188418	22.7376340	8.0259574	.001934236
518	268324	138991832	22.7596134	8.0311287	.001980502
519	269361	189798859	22.7815715	8.0362935	.001926782
520 521	270400 271441	140608000 141420761	22.8035085 22.8254244	8.0414515 8.0466030	.001923077
522	272484	142236648	22.8473193	8.0517479	.001915709
523	273529	143055667	22.8691933	8.0568862	.001912046
524 525	274576 275625	143877824 144703125	22.8910463 22.9128785	8.0620180 8.0671432	.001908397
526	276676	145581576	22.9346899	8.0722620	.001902141
527 528	277729 278784	146863183 147197952	22.9564806 22.9782506	8.0778748 8.0824800	.001897533
529	279841	148085889	23.0000000	8.0875794	.001893939 .001890859
530	280900	148877000	23.0217289	8.0926728	.001886792
531	281961	149721291	23.0434372	8.0977589	.001883239
532 533	283024 284089	150568768	23.0651252 23.0867928	8.1028390 8.1079128	.001879699
534	285156	151419437 152278304	23.1084400	8.1129808	.001876173 .001872659
535	286225	153130375	23.1300670	8.1180414	.001869159
53 6 53 7	287296 288369	153990656 154854153	23.1516738 23.1732605	8.1230962 8.1281447	.001865672 .001862197
538	289444	155720872	23.1948270	8.1331970	.001858786
539	290521	156590819	23.2163735	8.1382230	.001855288
540	291600	157464000	23.2379001	8.1482529	.001851852
541 542	292681 293764	158340421 159220088	23.2594067 23.2808935	8.1482765 8.1532939	.001848429 .001845018
543	294849	160103007	23.3023604	8.1583051	.001841621
544 545	295936 297025	160989184 161878625	23.3238076 23.3452351	8.1633102 8.1683092	.001838235
546	298116	162771336	23.3666429	8.1733020	.001834862 .001831502
547	299209	163667323	23.3880311	8.1782888	.001828154
548 549	300304 801401	164566592 165469149	23.4093998 23.4307490	8.1832695 8.1882441	.001824818 .001821494
550	802500	166375000	23.4520788	8.1932127	.001818182
551	803601	167284151	23.4733892	8.1981752	.001814882
552	804704	168196608	23.4946802	8.2031819	.001811594
558 554	805809 806916	169112377 170031464	23.5159520 23.5372046	8.2080825 8.2180271	.001808818 .001805054
555	308025	170953875	23.5584380	8.2179657	.001801802
556 557	309136 310249	171879616 172808693	23.5796522 23.6008474	8.2228985 8.2278254	.001 798561 .001 795882
558	811364	173741112	23.6220236	8.2327463	.001798115

CUBE ROOTS, AND RECIPROCALS.

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
559	812481	174676879	23.6431808	8.2876614	.001788909
660	313600	175616000	23.6643191	8.2425706	.001785714
561	814721	176558481	23.6854386	8.2474740	.001782581
562	815844	177504328	23.7065892	8.2523715	001779859
568	316969	178453547	23.7276210	8.2572633	.001776199
564	318096	179406144	23.7486842	8.2621492	.001778050
565 566	819225 820356	180862125 181821496	23.7697286 23.7907545	8.2670294	.001769912
567	321489	182284263	23.8117618	8.2719089 8.2767726	.001766784
568	822624	183250432	23.8827506	8.2816355	.001760568
569	828761	184220000	25.8587209	8.2864928	.001757469
570	824900	185193000	23.8746728	8.2913444	.001754886
571	326041	186169411	23.8956063	8.2961908	.001751818
572	827184	187149248	28.9165215	8.3010304	.001748252
578 574	828329 829476	188182517 189119224	23.9374184 23.9582971	8.3058651 8.3106941	.001745201
575	830625	190109875	23.9791576	8.3155175	.001739180
576	831776	191102976	24.0000000	8.3203353	.001736111
577	832929	192100033	24.0208243	8.3251475	.001738102
578	834084	193100552	24.0416306	8.8299542	.001730104
579	835241	194104539	24.0624188	8.8347558	.601727116
580	836400	195112000	24.0831891	8.8395509	.001724188
581 582	837561 838724	196122941 197137368	24.1039416 24.1246762	8.3443410 8.3491256	.001721170 .001718218
588	839889	198155287	24.1458929	8.8589047	.001715266
584	841056	199176704	24.1660919	8.3586784	.001712329
585	842225	200201625	24.1867732	8.3634466	.001709402
586	843396	201230056	24.2074369	8.3682095	.001706485
587	844569	202262003	24.2280829	8.8729668	.001708578
588 589	845744 846921	203297472 204336469	24.2487118 24.2698222	8.8777188 8.8824653	001700680 001697798
90	848100	205879000	24.2899156	8.3872065	.001694915
591	849281	206425071 207474688	24.8104916 24.8810501	8.3919428	.001692047
592 598	850464 851649	208527857	24.3515913	8.3966729 8.4013981	.001689189 .001686841
594	852836	209584584	24.3721152	8.4061180	.001688502
595	854025	210644875	24.3926218	8.4108326	.001680672
596	855216	211708736	24.4181112	8.4155419	.001677852
597	856409	212776173	24.4335834	8.4202460	.001675042
598 599	857604 858801	213847192 214921799	24.4540385 24.4744765	8.4249448 8.4296383	.001672241
500	860000	216000000	24.4948974	8.4348267	.001666667
6 01	861201	217081801	24.5153013	8.4390098	.001663894
602	862404	218167208	24.5356888	8.4486877	,001661130
608	863609	219256227	24.5560588	8.4483605	.001658375
604	864816	220348864	24.5764115	8.4530281	.001655629
605	366025 367236	221445125 222545016	24.5967478	8.4576906 8.4623479	.001652893
606 607	368449	223648543	24.6170678 24.6378,00	8.4670001	.001647446
608	869664	224755712	24.6576560	8.4716471	.001644737
609	870881	225866529	24.6779254	8.4762892	.001642036
610	872100 873321	226981000	24.6981781	8.4809261	.001689844
611 6 12	874544	228099131 229220928	24.7184142 24.7386388	8.4855579 8.4901848	.001636661
618	875769	230346397	24.7588368	8,4948065	.001631321
614	876996	281475544	24.7790234	8.4994233	.001628664
615	878225	232608375	24.79919 85	8.5040350	.001626016
616	879456	283744896	24.8193473	8.5086417	.001628377
617	380689	234885113	24.8394847	8.5182485	.001620746
618 619	881924 883161	236029032 237176659	24.8596058 24.8797106	8.5178408 8.5224821	.001618128 .001615509
620	884400	238328000	24.8997992	8.5270189	.001612908

TABLE V.—SQUARES, CUBES, ETC.

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
621	885641	289483061	24.9198716	8.5316009	.001610306
622	886884	240641848	24.9899278	8.5361780	.001607717
628	3881:29	241804867	24.9599679	8.5407501	.001605136 .001602564
6:24	389376	242970624	94.9799920 25.000000	8.5458178 8.5498797	.001600000
625	890625	244140625 245314876	25.000000	8. 544872	.001597444
626	891876	246491888	25.0399681	8.5589899	.001594896
627 628	393139 394384	247678152	25.0599282	8.5635377	.001592857
629	895641	248858189	25.0798724	8.5680607	.001589825
		250047000	25.0998008	8.5726189	.001587302
630	896900 898161	251289591	25,1197184	8.5771528	.001584786
631 632	399424	252485968	25,1396102	8.5816809	.001582278
633	400689	258636187	25.1594918	8.5862047	.001579779
634	401956	254840104	25.1798566	8.5907238	.001577287
635	408225	256017875	25.1992068	8.5952880 8.5997476	.001574808 .001572827
686	401496	257259456	25.2190404 25.2388589	8.6042525	.001569859
637	405769	258474858 259694072	25,2586619	8.6087526	.001567898
638 639	407044 408321	260917119	25.2784498	8.6132480	.001564945
			25,2982218	8.6177388	.001562500
640	409600	262144000 263374721	25.3179778	8.6222248	.001560062
641	410881 412164	264609288	25.3377189	8.6267068	.001557632
642 643	418449	265847707	25.3574447	8.6311830	.001555210
644	414786	267089984	25.3771551	8.6356551	.001552795
645	416025	268336125	25.8968502	8.6401226	.001550888
646	417316	269586136	25.4165301	8.6445855 8.6490487	.001547988
647	418609	270840023	25.4361947 25.4558441	8.6534974	.001543210
648	419904 421201	272097792 273359449	25.4754784	8.6579465	.001540632
649			25.4950976	8.6623911	.001588462
650	422500 423801	274625000 275894451	25.5147016	8.6668810	.001536098
651 652	425104	277167808	25.5342907	8.6712665	.001583742
658	426409	278445077	25.5538647	8.6756974	.001581894
654	427716	279726264	25.5734237	8.6801287	.001529052
655	429025	281011375	25.5929678	8.6845456	.001526718 .001524390
656	430.336	282800416	25.6124969	8.6889690 8.6933759	.001522070
657	431649	283593393 284890312	25.6320112 25.6515107	8.6977843	.001519757
658 659	482964 484281	286191179	25.6709958	8.7021882	.001517451
		287496000	25.6904652	8.7065877	.001515159
660	435600 436921	288804781	25.7099203	8.7109827	.001512859
661 662	430821	290117528	25.7293607	8.7153734	.001510574
663	489369	291434247	25,7487864	8.7197596	.001508296
664	440896	292754944	25.7681975	8.7241414	.001506024
665	442225	294079625	25.7875939	8.7285187 8.7328918	.001508759
666	443556	295408296	25.8069758 25.8263431	8.7372604	.001499250
667	444889 446224	296740963 298077632	25.8456960	8.7416246	.001497006
668 669	447561	299418309	25.8650343	8.7459846	.001494768
670	448900	800763000	25.8843582	8.7503401	.001492537
671	450241	802111711	25.9036677	8.7546918	.001490318
672	451584	803464448	25.9229628	8.7590888	.001488095
678	452929	804821217	25.9422435	8.7633809	.001485884
674	454276	306182024	25.9615100	8.7677192 8.7720532	.001483680
675	455625	807546875	25.9807621 26.000000	8.7720532 8.7763830	.001479290
676	456976 458329	808915776 810288733	26.000000 26.0192237	8.7807084	.001477105
677 678	4556329 459634	311665752	26.0384331	8.7850296	.001474926
679	461041	813046839	26.0576284	8.7893466	.001472754
690	462400	814432000	26.0768096	8.7936598	.001470588
681	463761	815821241	26.0959767	8.7979679	.001468429
682	465124	317214568	26.1151297	8.8022721	.001466276

CUBE ROOTS, AND RECIPROCALS.

No. Squares Cubes Square Ecots Cube Roots Reciprocals						
884 477866 320013504 28.1589897 8.8106861 .001441988 686 470506 2225288866 88.1916017 8.8194474 .001457736 687 470506 3225288866 88.1916017 8.8194474 .001457736 687 470506 3225288866 88.1916017 8.8194474 .001457736 688 4773844 325660732 36.22807841 8.8890099 .001458848 688 27767 .00145736 36.22808866 8.8282850 .001453878 689 4774721 327082769 36.2380736 8.8282850 .001453878 690 4771401 3259939371 26.23867799 8.8495227 .001447778 691 477481 3259939371 26.23867799 8.8495257 .001447778 691 477481 3259939371 26.23867799 8.8495257 .001447778 691 481636 325812507 26.3248982 8.8495065 4.001443001 .0014430	No.	Squares.	Cubes,		Cube Roots.	Reciprocals.
685 467856 830018604 26, 1589897 8, 81051598 .001451988 686 470566 822528866 26, 1916017 8, 8194474 .001457726 687 471369 822528866 26, 1916017 8, 8194474 .001457726 688 473844 825660672 26, 2297541 8, 8890099 .001458498 689 474721 825680672 26, 2297541 8, 8890099 .001451879 690 477481 825680600 26, 248696 8, 8222856 .001451879 691 477481 825680601 26, 2268769 8, 8458227 .001447187 692 478964 831873898 28, 305828 8, 8408227 .001447187 693 440249 823218507 26, 324882 8, 8450654 .001445087 694 481636 839450884 26, 348872 8, 855368 .00144921 696 483005 835718237 26, 3282837 8, 855368 .00144922 696 48416 837154836 26, 3818119 8, 823626 697 485809 8389608973 26, 4007576 8, 8668375 .00143730 698 485801 341583099 28, 4389061 8, 876489 .00143730 700 490000 24, 427010 28, 4764046 8, 8832661 .001438261 701 491401 344472101 28, 4764046 8, 8832661 .00142854 702 492904 345644069 36, 3638161 8, 903380 .00142877 704 49291 346408282 36, 518961 8, 903380 .00142877 705 492904 347649897 28, 51414728 8, 917063 .00142877 706 49849 36338243 26, 55896716 9, 903386 .00142877 707 49849 36338243 26, 55896716 9, 903386 .00142877 708 49849 36338243 26, 568816 9, 903386 .00142877 709 49849 36338243 26, 568861 9, 903386 .00142475 701 401401 344472101 28, 4764046 8, 8832661 .00142654 702 49849 36338243 26, 568861 9, 903386 .00142476 703 49849 36338243 26, 568868 8, 903880 .0014287 704 49849 36338243 26, 568868 8, 903880 .0014287 705 50044 36460829 26, 56886 8, 903386 .0014287 707 501100 87911000 26, 645823 8, 903866 .0014287 708 501265 808460829 26, 56880 8, 903386 .00140470 709 501404 364608028 26, 56880 8, 903866 .00148889 7014 50140 3791100 26, 645823 8, 903860 .0	688	466489	818611987	26,1842687		.001464129
B85					8.8108681	
686 470596 82288856 82.1916017 8.8194474 .001457726 687 471969 82288566 26.2977541 8.8827307 .001455604 688 473344 82560072 26.2297541 8.8820099 .001453488 689 4774721 827082769 26.2488005 8.8822850 .001453478 690 477481 82989871 26.2388789 8.8408227 .001447178 692 477864 82989871 26.2388789 8.8408227 .001447178 692 478864 832812557 26.2388799 8.8408227 .001447178 693 440249 832812557 26.3248982 8.489440 .001443001 694 4451636 83405534 26.3483797 8.855995 .00144022 695 448025 83702875 26.3028527 8.8578499 .001483649 696 448416 83716535 26.3818119 8.8608575 .00149282 697 448560 33806873 26.4007576 8.8608575 .001493720 698 447204 34008892 26.419680 8.874899 .001493655 699 488601 841582099 26.4386061 8.874999 .001493655 700 490000 34000000 26.4575131 8.8790400 .001493655 701 490240 345948408 26.4968286 8.874882 .001493651 702 492804 346948408 26.496286 8.874882 .001493651 703 494209 347428297 26.5141472 8917063 .001493651 704 496616 34913664 26.532998 8.8958904 .001493651 705 497025 850402635 26.5518861 8.904386 .001416437 706 496496 358486412 26.668286 8.9958904 .001493450 707 496496 358486412 26.668286 8.9958904 .001493450 708 501964 358480412 26.668286 8.9958904 .001493450 709 502681 356400829 26.645825 8.9958904 .001493450 701 506521 356406329 26.645825 8.9958904 .001493450 701 506521 356406329 26.645825 8.9958904 .001493450 701 506964 356406329 26.645825 8.9958905 .001406470 701 506964 356406329 26.645825 8.9958905 .001406470 703 506964 356406329 26.645825 8.9958905 .001406470 703 506964 36960613 36.656851 .00130664 704 506964 369606 367768179 36.6640889 .001406470 707 496969 367				26.1725047	8.8151598	
687 471969 324342703 26.2297641 8.829707 .00145094 .00145094 .00145348 .001451879 .00145094 .001451879 .0014518		470596	822828856	26.1916017		
Color						
Color	688	473344				
\$691 477481 289989871 381.3988789 8. 8468827 001445087 692 47884 331873898 28. 3058929 8. 845824 001445087 693 480249 332812877 28. 324982 8. 845844 001443001 694 481636 33425384 28. 3435797 8. 835865 001440828 695 485409 335608873 28. 3438797 8. 835865 001440828 696 484416 387158536 28. 3818119 8. 830962 001438782 697 485809 385608873 28. 4007576 8. 863876 001438782 698 487204 34006892 26. 4196896 8. 8746099 001439061 700 400000 34300000 26. 4576131 8. 8790400 001438061 701 401401 344472101 26. 4764046 8. 8832661 001436534 702 408909 347428927 26. 5141472 8. 8917063 001432475 703 404209 347428927 26. 5141472 8. 8917063 001432475 704 405613 348913664 36. 5323988 8. 891898 001434501 705 409408 34584868 26. 5706605 8. 9043986 001414427 706 409408 35886818 26. 5706605 8. 9043986 001414427 707 409409 363382834 26. 5594716 8. 906587 00141427 708 501364 334894012 26. 6083694 8. 9127389 00141427 709 502681 366400829 26. 6270539 8. 9163811 001410487 710 504100 267911000 26. 6458252 8. 9211914 001406470 711 506021 369425431 26. 6645833 8. 9259073 001404494 712 506044 300944128 26. 6853281 8. 938902 001404325 713 506369 383467097 26. 7026696 8. 9336687 001404325 716 511255 365625675 26. 7394899 8. 9449140 001396641 717 514069 389601613 26. 7765829 8. 945933 001400660 718 51524 370146232 26. 7055829 8. 945933 00140660 719 516661 37394809 26. 6270539 8. 945902 00139275 720 51840 37394600 26. 828577 8. 978766 00138503 721 51861 371694869 27. 7000000 0000000 001377410 722 527283 37785067 26. 948899 27. 9000000 001386613 723 528289 34440688 36. 9628577 39. 948899 39. 948898 39. 948898 39. 948898 39. 948898 3	689	474721	827082769	26.2488095	8.8322850	.001451879
601 477481 839898971 26. 28667789 8. 8408227 001447178 602 478984 831873898 26. 3058929 8. 8450854 001443001 603 490249 832812877 26. 3848932 8. 8458840 001443001 604 481635 38425884 26. 3848797 8. 855885 001440828 605 489025 385702875 26. 3628527 8. 8578489 001438732 606 484416 387154363 26. 3818119 8. 8620857 001438732 607 485809 388608973 26. 4196896 8. 874899 001438732 608 487204 34008392 26. 4196896 8. 8748099 001439265 609 488601 341582099 26. 4386061 8. 8748099 001439265 700 490000 34200000 26. 4576131 8. 8790400 001438574 701 491401 344472101 26. 4764046 8. 8832861 00143254 702 492804 345948406 26. 4562826 8. 8874832 001432547 703 494209 347428127 26. 5141472 8. 8817063 00143254 704 495616 348913964 26. 5252968 8. 884804 00142045 705 497025 360402625 26. 5518361 3901804 001418450 706 409496 363932845 26. 5594716 8. 968587 00141427 707 49949 363932845 26. 5694716 8. 968587 00141422 709 502881 366400829 26. 6645833 8. 921814 001410437 711 504010 357911000 26. 6458252 8. 921814 00140487 712 506044 360944128 26. 6685251 8. 9239078 001404470 713 506521 359425431 26. 6685251 8. 9239078 001404470 714 506521 369425431 26. 6685251 8. 9239078 001404870 715 511225 365625675 26. 7394898 8. 9480140 001396601 716 51265 36701696 3670508 36. 361805 00139664 717 514089 36894012 36. 6645833 8. 9259078 001404870 718 51524 37046232 36. 7507784 8. 987833 001406470 719 51661 371694959 36. 5645831 8. 9259078 001406470 719 516961 371694959 36. 5645831 8. 9259078 001406470 719 516961 371694959 36. 5645833 8. 9259078 001406470 719 516961 371694959 36. 5645831 8. 9480867 00139664 720 518400 3796461 3796664 3896667 389667 389667 389667 389667 389667 389667	800	478100	828509000	26.2678511	8.8365559	.001449275
692 47864 331873883 28. 30.56929 8. 8450854 001443001 694 481636 33425384 26. 3438797 8. 8395486 001443001 694 481636 33425387 28. 3438797 8. 8355485 001440829 695 483025 335702375 26. 3438797 8. 8355485 001440829 001448789 696 484416 337158536 36. 8818119 8. 839082 001488789 00148789 697 485809 33806873 26. 4007576 8. 8635875 001434739 698 487304 34008839 28. 4196896 8. 8705757 001432466 699 485801 341582099 28. 4386051 8. 8748099 001430515 001432730 00143253 00143					8.8408227	
698			831373888	26.3058929	8.8450854	.001445087
664 481636 38425384 48.83438797 8.8538985 001448789 665 483025 385702375 28.3628527 8.8538985 001438789 666 484416 387158368 28.63818119 8.8630852 001438782 667 485809 389608873 36.407576 8.863875 001434730 668 487204 34008382 26.4196896 8.8708757 001432465 669 485801 341532099 28.4386051 8.8748099 001438561 700 49000 34300000 28.4575131 8.8730400 001428571 701 491401 344472101 26.476406 8.8838261 001428571 702 492904 345048406 28.4052826 8.8974582 001424501 703 494209 347428327 28.5141472 8.8917063 001422475 704 495616 34913664 26.5329983 8.895890 0014242575 705 497025 38040262 26.5518361 8.901390 001422475 706 496436 381986816 26.5329983 8.895890 001442450 707 499649 35393243 26.5984716 8.9063967 001414427 708 501264 28468912 26.082694 8.9127389 001412429 709 502681 366400629 26.057639 8.9168311 001406470 711 505021 259425431 26.6832828 8.9259078 0014040787 712 506944 360944128 28.6832818 8.9259078 0014040787 713 506944 360944128 26.6832828 8.9259078 0014040787 714 509796 36394944 26.7907784 8.9378433 001402625 715 511225 365625675 26.7394899 8.946190 001392692 716 512656 38701696 26.7581763 8.946190 001392692 717 514089 368961813 26.7905859 8.946190 001392692 721 516961 371649859 26.7581763 8.946190 001392692 722 513244 370346232 26.79539 8.9468081 001393779 723 51840 373948000 26.883281 8.925906 001392752 724 527776 88667178 2777784 8.976857 001385042 725 52625 381078125 26.9258249 8.9659570 001392752 726 527776 883657176 26.7594899 8.9459140 001396601 727 728 52625 381078125 26.9258240 8.9659570 001392752 729 51840 37396361 26.870784 8.9768681 0013937769 729 538441 374805361 26.871767 8.9768673 001392769 720 518400 373948000 26.883815 9.9969870 001392752 721 519641 374805361 26.871767 8.996986970 001392769 722 51840 3750698 8.98691813 26.7565869 9.99686870 001385042 723 51840 3750698 8.98691813 26.7565869 001387890 001386683 723 518481 3874805361 26.871767 8.9969857 001385042 723 51840 3750698 7.7767857 8.9969857 001385042 724 54166 88988858 7.076789 9.082889 001386789 725 526525 381076135 7.7767857 8.9969			832812557			.001443001
686		481636	334255384			.001440922
697			885702375			
688						
\$699 438601 341533099 28.4386061 8.8734099 .001430615 \$700						
700 490000 348000000 28. 4575181 8. 8790400 .001428571 701 491401 344472101 26. 4764046 8. 8833661 .001428531 702 492804 345948408 36. 4652896 8. 8874882 .001424501 703 494209 347428927 26. 5141472 8. 8917063 .001422475 704 496616 348913864 28. 5529983 8. 8952904 .0014294501 705 497025 350402825 36. 5518361 8. 9013084 .001418440 706 496436 351896516 26. 5706605 8. 9043386 .001418440 707 49849 353393249 26. 5894716 8. 9058387 .001414427 708 501364 354894912 26. 6082894 8. 9127369 .001410437 709 502681 356400829 26. 6270539 8. 9169811 .001410437 710 504100 357911000 26. 6458252 8. 9211214 .001408451 711 505521 259425431 26. 6832981 8. 9234902 .001404404 713 508369 362467087 26. 6636838 8. 9253078 .001406470 712 506944 360944122 36. 6832981 8. 9234902 .001404494 713 508369 362467087 28. 7020598 8. 9336687 .001404494 713 508369 362467087 28. 7020598 8. 9336687 .001406470 716 51925 365525875 26. 7384839 8. 9480140 .001389601 717 514089 36960181 26. 7584783 8. 9480140 .001389601 718 515524 370142232 26. 7584783 8. 9480140 .001389601 718 515524 370142232 26. 7584783 8. 9480140 .001389601 718 515524 370142232 36. 7584839 8. 9480140 .0013896801 718 515524 370142232 36. 7585230 8. 9456299 .001389678 720 518400 373348000 26. 8328157 8. 9568581 .001389681 722 52729 37833067 28. 8866593 8. 9752406 .001389681 723 519641 374905861 36. 8741754 8. 9668570 .01389682 724 524176 373506424 26. 9772481 8. 9773600 .001387616 725 52625 881078125 36. 9258240 8. 985905 .001389780 726 527076 882657176 26. 9828875 8. 9773600 .001387616 727 5285599 48348588 36. 9228575 8. 9977630 .001377510 728 525998 884882585 27. 0738727 9. 0164299 .001387410 729 538444 401847272 27. 1661554 9. 0082829 .001387281 729 531441 887420489 27. 0000000 9. 000000 .001877142 720 538504 49868256 27. 12831199 9. 0287149 .001386968 721 54964 401847272 27. 1661554 9. 0082829 .001387280 723 54964 4018452 36. 9736769 9. 0531831 .001387360 724 549644 401847272 27. 1661554 9. 0088857 .001385614 729 54964 401847272 27. 1661554 9. 0088857 .001385614 729 54964 4018458 27. 2						
Total	699	488601	841582099			
TOLD	700	490000	343000000			
103	701					
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791 625681 494913671 28. 1247232 9. 3462844 1001943283 792 627384 49673908 82. 1247232 9. 2521300 001363636 793 628849 498677257 28. 1602587 9. 2560224 001261084 794 630438 500566184 28. 1780066 9. 2599114 001259446 795 633025 502459875 28. 1967444 9. 887979 001257682 796 633616 5043583836 28. 2134720 9. 2076798 001256981 797 635209 506261573 28. 2311884 9. 2775582 001256981 799 638401 506163952 28. 2486988 9. 2778081 001251664 800 640000 518000000 28. 2842712 9. 2881777 00125000 801 641601 518922401 28. 3019434 9. 9870440 00124688 803 644809 517781627 28. 3872546 9. 2947671 00124688 804 6461616 519718462 28. 3649388 <td< td=""><td></td><td></td><td></td><td></td><td></td><td></td></td<>						
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798 628849 498677257 28.1602557 9.2660234 .001361084 794 630438 500566184 28.1780056 9.2599114 .001259446 795 632025 502459675 28.1967444 9.2657973 .001257862 796 638616 504358383 28.2134720 9.2676798 .001256261 797 636209 506261673 28.2311884 9.2754552 .001256276 798 638604 506169592 28.248988 9.2754852 .001256183 800 640000 519000000 28.2842712 9.2831777 .00125000 801 641601 518922401 28.3018434 9.2870440 .00124683 808 644809 517781627 28.3372546 9.2947671 .001245880 804 646416 519718464 28.3649388 9.286239 .0012438286 805 648025 521660125 28.7372519 9.3004771 .001245880 904 64616 51871680127 28.3872546 9.2947671 </td <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>						
794 630436 500566184 28.1780066 9.2599114 001259446 795 632025 502459675 28.1807444 9.2687978 001257862 796 638616 504358386 28.2184720 9.2676798 001256861 797 638509 506261573 28.2311884 9.2715592 001254705 798 638604 508169592 28.2489888 9.2754352 001253183 799 638401 510082399 28.2866881 9.2798081 001251664 800 640000 512000000 28.2842712 9.2881777 001250000 801 641601 518922401 28.3194344 9.2870440 001244688 808 644809 51764868 28.3196045 9.2909072 001244688 804 646416 519718464 28.3848988 9.2947671 001248580 804 648025 521660125 28.3725219 9.3847671 0013482866						
795 632025 502459675 28.1867444 9.2667973 .001287682 796 638216 504383836 28.134720 9.2676798 .001254905 797 635209 506261573 28.2311884 9.2715592 .001254705 798 638604 560169592 23.2468988 9.2754852 .00125183 799 638401 510002000 28.2842712 9.2881777 .001251664 800 640000 512000000 28.2842712 9.2870440 .001246489 801 641601 513922401 28.3019434 9.2870440 .001246489 808 644809 517761627 28.3872546 9.2947671 .001245890 804 64616 519718464 28.384988 9.2896239 .001245280 805 648025 521660125 28.3725219 9.3826239 .0012452806			500566184			
796 638616 5043583836 28.2134720 9.2676798 .001254205 797 635209 506261573 28.2311684 9.2715592 .001254705 798 636804 508169592 28.2486988 9.2754552 .001254183 799 638401 510082399 28.2665851 9.2793061 .001251564 800 640000 513000000 28.2842712 9.2881777 .00125000 801 641601 513922401 28.3019434 9.2870440 .001246489 802 643204 515849608 28.3196045 9.209072 .00124688 808 644809 517761627 28.3872546 9.2947671 .001244839 804 646416 519718464 28.3548988 9.2966239 .00124781 805 648025 52160125 28.3725219 9.3024775 .001348286			502459875			
797 635209 506201573 28. 2311884 9. 2715592 .001254705 798 63804 508169592 28. 2485988 9. 2754353 .001253183 799 638401 510062399 28. 2866881 9. 2798081 .001251664 800 640000 512000000 28. 2842712 9. 2881777 .001250000 801 641601 513922401 28. 3019434 9. 2870440 .001246489 808 644804 517781687 28. 3872546 9. 29947671 .001245890 804 646416 519718464 28. 3548988 9. 2986239 .001243781 805 648025 521660125 28. 3725219 9. 3884765 .0013482866	796	633616	504358336			
799 638401 510082890 28.2665881 9.2798081 .001251664 800 640000 518000000 28.2842712 9.2881777 .001250000 801 641601 518922401 28.3019434 9.2870440 .001249489 802 643204 515849608 28.3199045 9.2909072 .001249488 808 644809 517781627 28.3872546 9.2947671 .001245890 804 646416 519718464 28.3548988 9.2966239 .001249781 805 648025 521660125 28.3725219 9.8024775 .001348286			506261573			
800 640000 512000000 28.2842712 9.2851777 .001250000 601 641601 513922401 28.3019434 9.2870440 .001248489 802 643204 515849608 28.3196045 9.2909072 .001248489 808 644809 517781627 28.3872546 9.2947671 .001245890 804 646416 519718464 28.3649388 9.2866239 .001243781 805 648025 521660125 28.73725219 9.3024775 .001248286						
801 641601 518922401 28.8016434 9.8970440 .001846489 802 648304 518849608 28.196045 9.29097072 .001246968 808 644809 517781627 28.8372546 9.2947671 .001246880 804 646416 519718464 28.8549388 9.2896239 .001243781 805 648025 521660125 28.73725219 9.8024775 .001348286	•••				•	
802 648304 515849608 28.8196045 9.2909072 .001246883 808 644809 517781627 28.3872546 9.2947671 .001246880 804 646416 519718464 28.8548989 9.2969329 .001349761 805 648025 521660125 28.8725219 9.8024775 .001349286					9.2870440	
808 644809 517781687 28.8378546 9.3947877 001348580 804 646416 519718464 28.8548988 9.2986239 001343781 805 648025 521660125 28.8725219 9.8034775 0013485286	802	643204				
804 646416 519718464 28.8548938 9.2966239 .001242781 .005 648025 521660125 28.8725219 9.8024775 .001242236	808		517781627	28.8372546	9.2947671	
	804	646416				.001243781
	805 806	648025 649636	521660125 523606616	28.3725219 28.3901391	9.8024775 9.8068278	.001242296 .001240695

CUBE ROOTS, AND RECIPROCALS.

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
807 808 809	651249 652864 654481	525557943 527514112 529475129	28.4077454 28.4258408 28.4429258	9.3101750 9.3140190 9.3178599	.001289157 .001287624 .001236094
810	656100	581441000	28.4604989	9.3216975	.001234568
811	657721	533411731	28.4780617	9.3255320	.001233046
812 813	659344 660969	535387328 537367797	28.4956137 28.5131549	9.3293684 9.3831916	.001231527 .001230012
814	662596	539353144	28.5306852	9.3370167	.001228501
815	664225	541343375	28.5482048	9.3408386	.001226994
816 817	665856 667489	543338496 545338513	28.5657187 28.5832119	9.3446575 9.3484781	.001225490 .001223990
818	669124	547343432	28.6006993	9.3522857	.001222494
819	670761	549353259	28.6181760	9.3560952	.001221001
820	672400	551368000	28.6356421	9.3599016	.001219512
821 822	674041 675684	553387661 555412248	28.6530976 28.6705424	9.3637049 9.3675051	.001218027 .001216545
823	677329	557441767	28.6879766	9.3713022	.001215067
824	678976	559476224	28.7054002	9.3750963	.001213592
825 826	680625 682276	561515625 563559976	28.7228132 28.7402157	9.3788873 9.3826752	.001212121
827	683929	565609283	28.7576077	9.3864600	.001209190
828	685584	567663552	28.7749891	9.3902419	.001207729
829	687241	569722789	28.7923601	9.3940206	.001206273
830 831	688900 690561	571787000 573856191	28.8097206 28.8270706	9.3977964 9.4015691	.001204819
832	692224	575930868	28.8444102	9.4053387	.001203309
833	693889	578009537	28.8617394	9.4091054	.001200480
834 835	695556 697225	580093704 582182875	28.8790582 28.8963666	9.4128690 9.4166297	.001199041
836	698896	584277056	28.9136646	9.4203873	.001196172
837	700569	586376253	28.9309523	9.4241420	.001194743
838 839	702244 703921	588480472 590589719	28.9482297 28.9654967	9.4278936 9.4316423	.001198317
840	705600	592704000	28.9827535	9.4353880	.001190476
841	707281	594823821	29.0000000	9.4391307	.001189061
842	708964	596947688	29.0172363	9.4428704	.001187648
843 844	710649 712336	599077107 601211584	29.0344623 29.0516781	9.4466072 9.4503410	.001186240
845	714025	603351125	29.0688837	9.4540719	.001183432
846	715716	605495736	29.0860791	9.4577999	.001182033
847 848	717409 719104	607645423 609800192	29.1032644 29.1204396	9.4615249 9.4652470	.001180638 .001179245
849	720801	611960049	29.1376046	9.4689661	.001177856
850	722500	614125000	29.1547595	9,4726824	.001176471
851	724201	616295051	29.1719043	9.4763957	.001175088
852 853	725904 727609	618470208 620650477	29.1890390 29.2061637	9.4801061 9.4838136	.001173709
854	729816	622835864	29.2232784	9.4875182	.001170960
855	781025	625026375	29.2403830	9.4912200	.001169591
856 857	732736 734449	627222016 629422793	29.2574777 29.2745623	9.4949188 9.4986147	.001168224 .001166861
858	736164	631628712	29.2916370	9.5023078	.001165501
859	737881	633839779	29.3087018	9.5059980	.001164144
860	739600	636056000	29.3257566	9.5096854	.001162791
861 862	741321 743044	638277381 640503928	29.3428015 29.3598365	9.5133699 9.5170515	.001161440
863	744769	642735647	29.3768616	9.5207303	.001158749
864	746496	644972544	29.3938769	9.5244063	.001157407
865 866	748225 749956	647214625 649461896	29.4108823 29.4278779	9.5280794 9.5317497	.001156069 .001154734
867	751689	651714363	29.4448637	9.5354172	.001153403
868	753424	653972032	29.4618397	9.5390818	,001152074

TABLE V.—SQUARES, CUBES, SQUARE ROOTS,

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocal
869	755161	656234909	29.4788059	9.5427437	.001150748
870	756900	658503000	29.4957624	9.5464027	.001149425
871	758641	660776311	29.5127091	9.5500589	.001148106
872	760384	663054848	29.5296461	9.5587128	.001146789
878	762129	665338617	29.5465734	9.5578630	.001145475
874	763876	667627624	29.5634910	9.5610108	.001144165
875	765625 767876	669921875 672221876	29.5803989 29.5972972	9.5646559 9.5682982	.001142857 .001141558
876 877	769129	674526133	29.6141858	9.5719877	001140251
878	770884	676836152	29.6310648	9.5755745	.001138952
879	772641	679151489	29.6479842	9.5792085	.001137656
880	774400	681472000	29.6647939	9.5828397	.001136364
881	776161	683797841	29.6816442	9.5864682	.001135074
882	777924	686128968	29.6984848	9.5900939	.001133787
883 884	779689 781456	688465387 690807104	29.7153159 29.7321375	9.5937169 9.5973878	.001132503
885	788225	698154125	29.7489496	9.6009548	.001131222
886	784996	695506456	29.7657521	9.6045696	.001128668
887	786769	697864103	29.7825452	9.6081817	.001127396
888	788544	700227072	29.7993289	9.6117911	.001126126
889	790321	702595369	29.8161030	9.6153977	.001124859
890	792100	704969000	29.8328678	9.6190017	.001123596
891	793881	707847971	29.8496231	9.6226080	.001122834
892 893	795664	709732288	29.8663690 29.8831056	9.6262016 9.6297975	.001121076
894	797449 799236	712121957 714516984	29.8998328	9.6333907	.001118568
895	801025	716917875	29.9165506	9.6369812	001117818
896	802816	719323136	29.9332591	9.6405690	.00111607
897	804609	721734273	29.9499583	9.6441542	.001114827
898 899	806404 808201	724150792 726572699	29.9666481 29.9833287	9.6477367 9.6513166	.001118586
900	810000	729000000	80.0000000	9.6548938	.001111111
901	811801	781432701	80.0166620	9.6584684	.001109878
902	813604	733870808	80.0333148	9.6620403	.001108647
903	815409	736314327	80.0499584	9.6656096	.001107420
904	817216	738763264	80.0665928	9.6691762	.001106190
905	819025	741217625	80.0832179	9.6727403	.001104972
906 907	820836 822649	743677416 746142643	80.0998389 80.1164407	9.6768017 9.6798604	.001108758 .001102536
908	824464	748613312	30.1330383	9.6834166	.00110132
909	826281	751089429	80.1496269	9.6869701	.001100110
910	828100 829921	758571000	80.1662063 80.1827765	9.6905211	.001098901
911 912	881744	756058081 758550528	30.1993377	9.6940694 9.6976151	.001096491
913	833569	761048497	30.2158899	9.7011583	.001095290
914	835396	763551944	80.2324329	9.7046989	.001094092
915	837225	766060875	80.2489669	9.7082369	.001092896
916	839056	768575296	80.2654919	9.7117728	.001091703
917	840889	771095213	80.2820079	9.7153051	.001090518
918 919	842724 844561	773620632 776151559	80.2985148 80.8150128	9.7188354 9.7223631	.001089325
920	846400	778688000	80.3315018	9.7258883	.001086957
921	848241	781229961	80.3479818	9.7294109	.001085776
922	850084	783777448	80.3644529	9.7329309	.001084599
928	851929	786330467	80.8809151	9.7364484	.001083428
924	853776	788889024	30.3973683	9.7399634	.001082251
925 926	855625 857476	791453125 794022776	80.4138127 30.4302481	9.7434758 9.7469857	.001081081
927	859329	796597983	80.4466747	9.7504930	.001078749
928	861184	799178752	30.4630924	9.7539979	.001077586
929	863041	801765089	80.4795018	9.7575002	.001076426
980	864900	804357000	30.4959014	9.7610001	.001075269

CUBE ROOTS, AND RECIPROCALS.

<u> </u>				1	
No.	Squares.	Cubes,	Square Roots.	Cube Roots.	Reciprocals.
981	866761	806954491	80.5122926	9.7644974	.001074114
982	868624	809557568	80.5286750	9.7679922	.001072961
988	870489	812166237	80.5450487	9.7714845	.001071811
984	872356	814780504	80.5614186	9.7749743	.001070664
985 986	874225 876096	817400875	80.5777697	9.7784616	.001069519
987	877969	820025856 822656958	80.5941171 80.6104557	9.7819466 9.7854288	.001068876
988	879844	825298672	80.6267857	9.7889087	.001066098
939	881721	827986019	80.6481069	9.7928861	.001064968
940	888600	830584000	80.6594194	9.7958611	.001063830
941	885481	883237621	30.6757288	9.7998886	.001062699
942 943	887864 889249	835896888 838561807	30.6920185 30.7083051	9.8028036 9.8062711	.001061571
944	891186	841232384	80.7245880	9.8097862	.001059322
945	893025	843908625	80.7408528	9.8131989	.001058201
946	894916	846590536	30.7571130	9.8166591	.001057082
947	896809	849278123	80.7733651	9.8201169	.001055966
948 949	898704 900601	851971892 854670849	30.7896086 30.8058486	9.8235723 9.8270252	.001054852
950	902500		30.8220700	9.8804757	.001052632
951	904401	857375000 860085851	30.8382879	9.8889288	.001062682
952	906304	862801408	30.8544972	9.8878695	.001050420
953	908209	865523177	80.8706981	9.8408127	.001049818
954	910116	868250664	30.8868904	9.8442536	.001048218
955 956	912025 913986	870983875	80.9080748	9.8476920 9.8511280	.001047120
957	915849	878722816 876467498	30.9192497 30.9854166	9.8545617	.001046025
958	917764	879217912	80.9515751	9.8579929	.001043841
959	919681	881974079	80.9677251	9.8614218	.001042758
960	921600	884786000	80.9838668	9.8648488	.001041667
961	923521	887508681	81.0000000	9.8682724	.001040588
962 963	925444 927369	890277128 893056847	81.0161248 81.0822413	9.8716941 9.8751185	.001039501 .001038422
964	929296	895841844	31.0483494	9.8785805	.001087844
965	981225	898632125	31.0644491	9.8819451	.001086269
966	933156	901428696	81.0805405	9.8858574	.001085197
967	985089	904231063	31.0966236	9.8887678	.001034126 .001032058
968 969	987024 988961	907089282 909858209	31.1126984 31.1287648	9.8921749 9.8955801	.001081992
970	940900	912673000	81.1448280	9.8989830	.001080928
971	942841	915498611	81.1608729	9.9028885	.001029866
972	944784	918380048	81.1769145	9.9057817	.001028807
978	946729	921167817	81.1929479	9.9091776	.001027749
974	948676 950625	924010424 926859875	81.2089781 81.2249900	9.9125712 9.9159624	.001026694
975 976	952576	929714176	81.2409987	9.9198518	.001024590
977	954529	932574888	81.2569992	9.9227879	.001028541
978	956484	935441352	81.2729915	9.9261222	.001022495
979	958441	938318789	81.2889757	9.9295042	.001021450
980	960400	941192000	31.3049517	9.9828889	.001020408
981 982	962361 964824	944076141 946966168	81.8209195 81.8368792	9.9362613 9.9396363	.001019368 .001018380
988	966289	949862087	81.8528308	9.9480092	.001010300
984	968256	952763904	81.8687748	9.9468797	.001016260
985	970225	955671625	81.8847097	9.9497479	.001015228
986	972196	958585256	81.4006869	9.9581188	.001014199
987 988	974169 976144	961504803 964430272	31.4165561 81.4824678	9.9564775 9.9598389	.001018171 .001012146
989	978121	967861669	81.4483704	9.9631981	.001011122
990	980100	970299000	81.4642654	9.9665549	.001010101
991	982081	973242271	31.4801525	9.9699095	.001009082
992	984064	976191488	81.4960315	9.9732619	.001008065

TABLE V.-SQUARES, CUBES, SQUARE ROOTS,

No.	Squares.	Cubes,	Square Roots.	Cube Roots.	Reciprocals.
998	986049	979146657	81.5119025	9.9766120	.001007049
994	988086	982107784	81.5277655	9.9799599	.001006036
995	990025	985074875	81.5436206	9.9833055	.001005025
996	992016	988047936	81.5594677	9.9866488 9.9899900	.001004016
997 998	994009 996004	991026973 994011992	81.5753068 81.5911380	9.9933289	.001003009 .001002004
999	998001	997002999	81.6069618	9.9966656	.001001001
1000	1000000	1000000000	81.6227766	10.0000000	.001000000
1001	1002001	1003003001 1006012008	81.6385840 81.6548896	10.0033322 10.0066622	.0009990010
1002 1003	1004004	1009027027	81.6701752	10.0099899	.0009980040
1004	1008016	1012 48064	81.6859590	10.0133155	.0009960159
1005	1010025	1015075125	81.7017849	10.0166389	.0009950249
1006	1012036	1018108216	81.7175030	10.0199601	.0009940858
1007	1014049	1021147343	31.7332633	10.0232791	.0009930487
1008	1016064	1024192512	81.7490157 81.7647608	10.0265958	.0009920685
1009	1018081	1027243729		10.0299104	.0009910908
1010	1020100	1080301000	81.7804972	10.0832228 10.0865330	.0009900990
1011	1022121 1024144	1033364331 1036433728	81.7962262 81.8119474	10.0808330	.0009891197
1012 1013	1026169	1039509197	81.8276609	10.0383410	.0009871668
1014	1028196	1042590744	81.8433666	10.0464506	.0009861933
1015	1030225	1045678375	31.8590646	10.0497521	.0009852217
1016	1032256	1048772096	81.8747549	10.0530514	.0009842520
1017	1034289	1051871913	81.8904374	10.0563485	.0009882842
1018	1036324	1054977832	81.9061128	10.0596435	.0009823183
1019	1038361	1058089859	81.9217794	10.0629364	.0009813543
10:20	1040400	1061208000	81.9374388	10.0662271	.0009808922
1021 1022	1042441 1041484	1064332261 1067462648	31.9530906 31.9687347	10.0695156 10.0728020	.0009794319
1023	1046529	1070399167	81.9843712	10.0760863	.0009775171
1024	1048576	1073741824	82.(000000	10.0793684	.0009765625
1025	1050625	1076890625	82.0156212	10.0826484	.0009756098
1026	1052676	1080045576	82.0312348	10.0859262	.0009746589
1027	1054729	1083206683	82.0468407	10.0892019	.0009787098
1028	1056784	1036373952	82.0624391	10.0924755	.0009727626
1029 1030	1058841 1060900	1039547389 1092727000	32.0780298 32.0936131	10.0957469 10.0990163	.0009718173
1031	1062961	1095912791	82.1091887	10.1022835	.0009699321
1032	1065024	1099104768	82.1247568	10.1055487	.00 9689922
1033	1067089	1102302937	82.1403178	10.1088117	.0009680542
1034	1069156	1105507304	82.1558704	10.1120726	.0009671180
1035	1071225 1073296	1108717875	32.1714159	10.1158314	.0009661886
1036 1037	1075369	1111934656 1115157653	82.1869539 82.2024844	10.1185882 10.1218428	.0009652510
1038	1075369	1118386872	32.2180074	10.1210428	.0009633911
1039	1079521	1121622319	82.2335229	10 1283457	.0009624639
1040	1081600	1124864000	82.2490310	10.1815941	.0009615385
1041	1083681	1128111921	82.2645316	10.1848403	.0009606148
1042	1085764	1131366088	82.2800248	10.1880845	.0009596929
1043 1044	1087849 1089936	1134626507 1137893184	32.2955105 32.3109888	10.1418266 10.1445667	.0009587788
1044	1099025	1141166125	32.3264598	10.1445007	.0009569378
1046	1094116	1144445336	82.3419233	10 1510406	.0009560229
1047	1096209	1147730823	82.8578794	10 1542744	.0009551098
1048	1098304	1151022592	82.3728281	10.1575062	.0009541985
1049	1100401	1154320649	82.3882695	10.1607359	.0009532888
1050	1102500	1157625000	82.4037035	10.1639636	.0009523810
1051 1052	1104601	1160935651 1164252608	82.4191301	10.1671898	.0009514748
1058	1106704 1108809	1167575877	82.4345495 82.4499615	10.1704129 10.1736344	.0009505708
1054	1110916	1170905464	82.4653662	10.1768539	.0009487666

Table VI.—Deflection Angles for a Spiral when the Chord $= R_1 \div 60$.

Sta. 0	Sta. 1	Sta. 2	Sta. 3	Sta. 4	Sta. 5	Sta. 6	Sta. 7
li li	=60C	R = 30C	R = 20C	R = 15C	R = 12C	R = 10C	R=8.6C
Ins. at 0	0° 29' ns. at 1 0 48 0 53 1 02 1 12 1 21 1 81	1° 12′ 1 26 Ins. at 2 2 04 2 28 2 42 3 01 3 21	2° 14′ 2 88 3 06 Ins. at 3 4 04 4 82 5 01 5 80	8° 85′ 4 08 4 46 5 25 Ins. at 4 6 41 7 20 7 58	5° 15′ 5 58 6 46 7 34 8 21 Ins. at 5	7° 14′ 8 07 9 04 10 02 10 59 11 56 Ins. at 6	9° 32′ 10 35 11 42 12 49 13 55 15 02

TABLE VII.—RADII, FROG ANGLES, AND FROG DISTANCES FOR GIVEN NUMBER OF FROG.

No. of Frog.	Radius.	Frog Angle.	Frog Distance.	No. of Frog.	Radius.	Frog Angle.	Frog Distance.
2 21/5 8 31/5 4 41/5	Feet. 37.66 58.85 94.75 115.35 150.67 190.67 235.41	28° 04′ 22° 37 18° 55 16° 16 14° 15 12° 41 11° 25	Feet. 18.83 23.54 28.25 32.96 37.66 42.37 47.08	5 516 6 616 7 716	Feet. 235.41 284.83 338.99 397.83 461.39 529.65 602.63	11° 25′ 10 23 9 32 8 48 8 10 7 38 7 09	Feet. 47.08 51.79 56.50 61.20 65.91 70.62 75.38

TABLE VIII.—FROG ANGLES AND FROG DISTANCES FOR GIVEN RADIUS.

Radius. Frog Distance. Feet. Feet.				0117					
35 29° 04' 18.15 60 22° 24' 23.77 85 18° 53' 28.29 36 28 41 18.41 61 22 18 23.96 86 18 47 28.62 37 28 19 18.67 62 22 03 24.16 87 18 40 28.62 38 27 75 18.92 63 21 52 24.36 88 18 34 28.79 40 27 16 19.40 65 21 33 24.74 90 18 22 29.11 41 26 57 19.65 66 21 23 24.93 91 18 16 29.21 42 26 38 19.89 67 21 13 25.12 92 18 10 29.43 44 26 03 20.36 69 20 55 25.49 94 17 59			Dis-		Frog Angle.	Dis.		Frog Angle.	Dis-
	35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 54 55 56 57 59	28 41 28 19 27 57 27 36 56 57 26 26 20 25 45 25 48 25 48 25 48 24 42 24 28 24 28 22 28 23 28 24 48 22 28 22 28 28 22 28 28 22 28 28 22 28 28 22 28 28 28 22 28 28 28 22 28 28 28 28 28 28 28 28 28 28 28 28 2	18.15 18.41 18.67 18.92 19.16 19.40 19.69 20.12 20.36 20.50 20.81 21.04 21.24 21.24 21.24 21.24 21.24 22.13 22.13 22.14 22.57 22.13 22.57 22.57 22.57 22.57 22.57 23.57 23.57	60 62 63 64 65 66 67 68 69 71 73 74 75 76 77 80 81 82 83	22 18 22 052 21 42 21 23 21 23 21 18 21 23 21 18 21 055 20 47 20 88 20 30 20 21 20 13 20 057 19 50 19 42 19 28 19 21 19 14 19 07	23.76 24.16 24.35 24.74 24.55 24.74 24.55 25.80 25.86 26.57 26.57 27.79 27.44 27.79 27.19 28.19	85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 115 115 120 125 120 125 145	18 47 18 304 18 28 18 18 22 18 16 16 18 10 17 59 17 47 17 42 17 32 17 26 17 17 15 56 15 37 15 15 19 15 02 14 46 14 31	28. 29 28. 48 28. 79 28. 79 28. 79 29. 11 29. 27 29. 48 29. 57 29. 18 30. 69 31. 44 31. 83 34. 39 35. 66 36. 31 36. 36 36. 31

TABLE IX.—USEFUL NUMBERS AND FORMULÆ.

Title.	Symbol.	Number.	Loga- rithm.
Ratio of circumference to diameter	π	8.1415927	0.4971499
Reciprocal of same	1_	0.8183099	9.5028501
Degrees in arc of length equal to radius	π 180° π	57.295780	1.7581226
Minutes " " " " …	10800′	8487.7468	8.5862789
Seconds " " " "	648000°	206264.81	5.8144251
Length of 1° arc, radius unity	π 180°	.01745829	8.2418774
Length of 1' arc, " "	π' 10800	.00029089	6.4687261
Length of 1' arc, " "	π' 648000	.000004848	4.6855749
Radius by which 1 foot of arc = 1 degree.		57.295780	1.7581226
Radius " $\frac{1}{10}$ " " = 1 minute.		348.77468	2.5362739
Radius " " 100 " = 10 seconds		206.26481	2.8144251
Factors for dividing a line into extreme)		0.6180340	9.7910124
and mean ratio		0.8819660	9.5820248
Base of hyperbolic logarithms	ε	2.7182818	0.4342945
Modulus of common system of logs. $=\log arepsilon$	M	0.4342945	9.6377843
Reciprocal of same = hyp. log. 10	<u>1</u> <u>M</u>	2.3025851	0.8622157
Length of seconds pendulum at New York			
in inches		89.11256	1.5923162
Length of seconds pendulum at New York			
in feet		8.25938	0.5181850
Acceleration due to gravity at New York	g	82.1688	1.5074847
Square root of same	√g	5.67175	0.7587178
Yards in 1 metre		1.093628	0.0388676
Feet in 1 "		8.280869	0.5159889
Inches in 1 "		89.87048	1.5951701
Metres in 1 foot	ļ	0.804797	9.4840111
Metres in 1 yard		0.914892	9.9611324
Metres in 1 mile		1609.890	8.2066450

TABLE IX.—USEFUL NUMBERS AND FORMULÆ

Title.	Symbol.	Number.	Loga- rithm.
Cubic inches in 1 U.S. gallon		231.	2.3636120
" " 1 Imperial gallon		277.274	2.4429092
" " 1 U. S. bushel		2150.42	3.8825233
Cubic feet in 1 U.S. gallon		0.133681	9.1260683
" " 1 Imperial gallon		0.160459	9.2053655
" " 1 U. S. bushel		1.244456	0.0949796
Weight of 1 cub. foot of water, barom. 30 in.			1
ther. 39°.83 Fah.; pounds		62.379	1.7950384
·· 62° ·· ··		62.321	1.7946849
Weight in grains, 1 cubic inch, at 62° Fah		252.458	2.4021892
No. of grains in 1 pound avoir		7000.	3.8450980
" " " 1 ounce "		437.5	2.6409781

$$r={
m radius} \ {
m of} \ {
m circular} \ {
m arc};$$
 $l={
m length} \ {
m of} \ {
m arc};$ $a^{\circ}={
m degrees} \ {
m in} \ {
m same} \ {
m arc}.$ $r=rac{l}{a^{\circ}}\cdotrac{180^{\circ}}{\pi}$ $l=a^{\circ}r\cdotrac{1}{\pi}$ $l=a^{\circ}r\cdotrac{1}{\pi}$

Radius by which the length of chord c in feet $=\frac{a'}{10}$ in minutes;

$$r = \frac{\frac{1}{10}a'}{10\sin\frac{1}{10}a'}$$

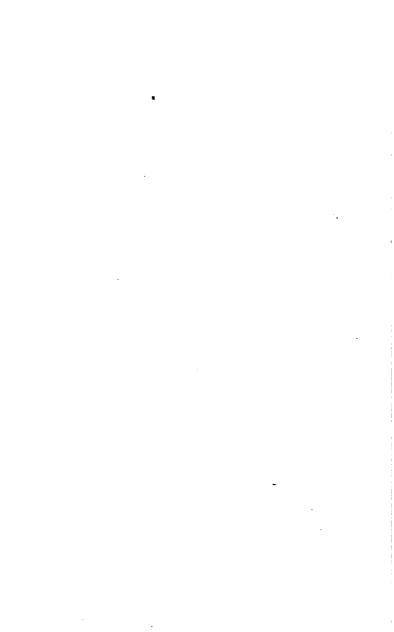
Hyp. $\log x = \text{com. } \log x \times \frac{1}{M}$, or

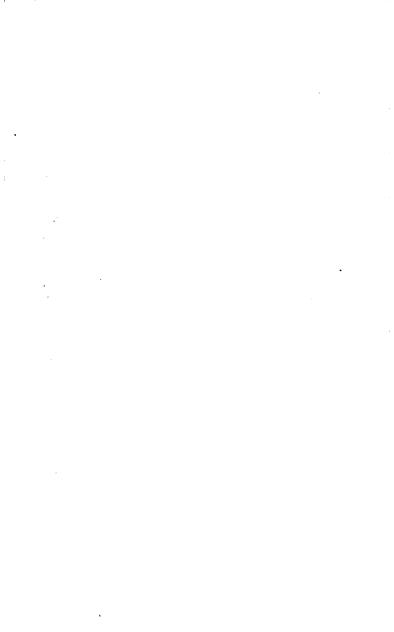
com. $\log (\text{hyp. log } x) = \text{com. log } (\text{com. log } x) + 0.3622157$

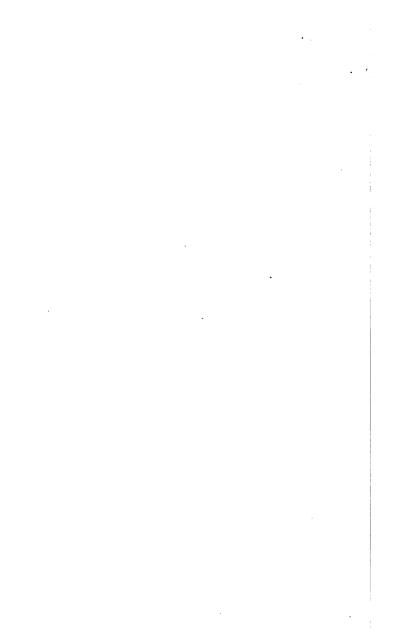
Com. $\log x = M \times \text{hyp. } \log x$; or

com. $\log (\text{com. } \log x) = 9.6377843 + \text{com. } \log (\text{hyp. } \log x)$

Approximate area of segment (chord = c, mid. ord. = m) %cm

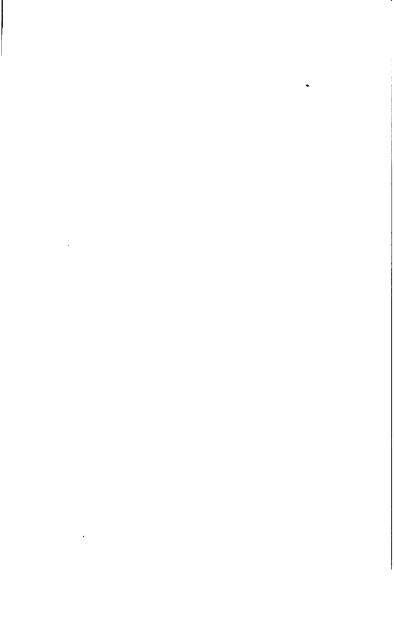


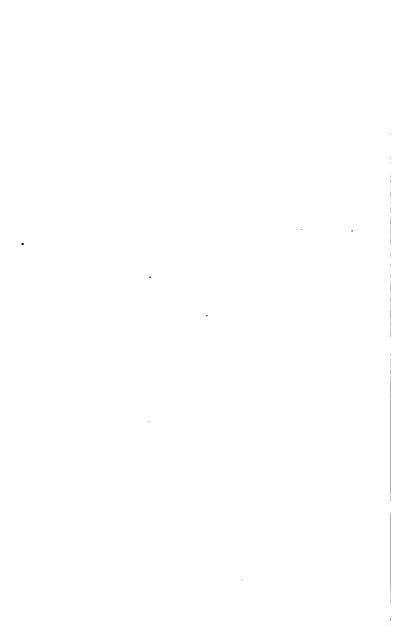


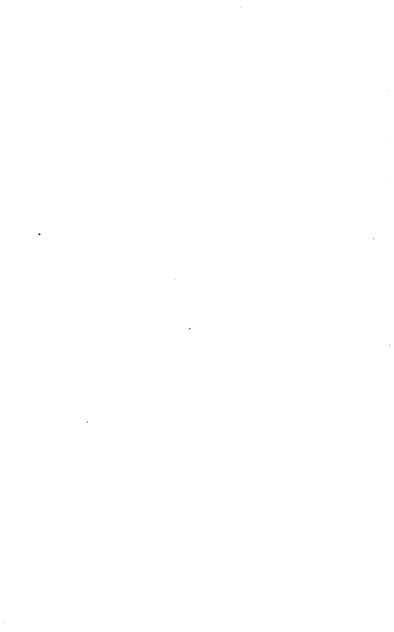








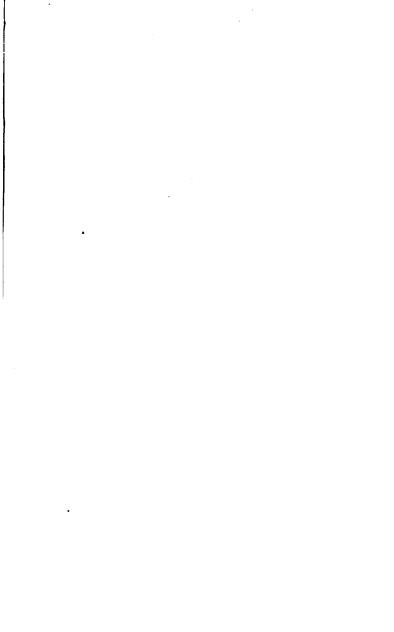


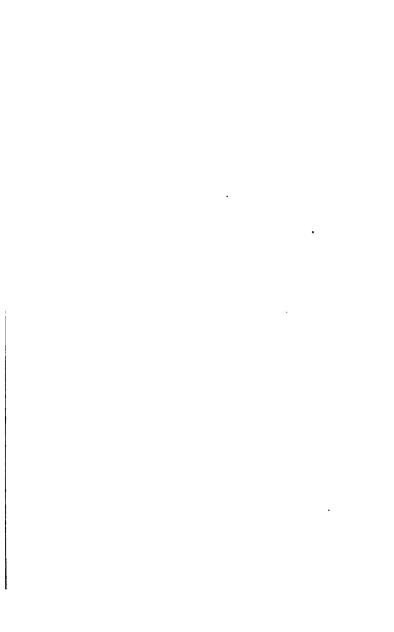


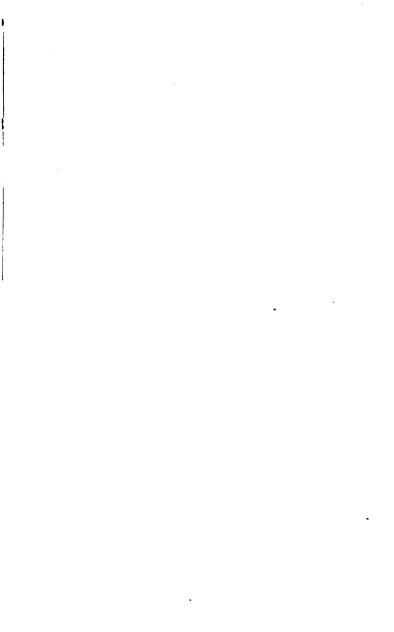
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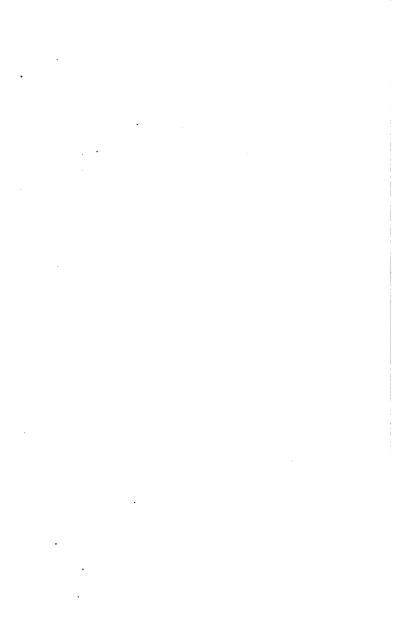
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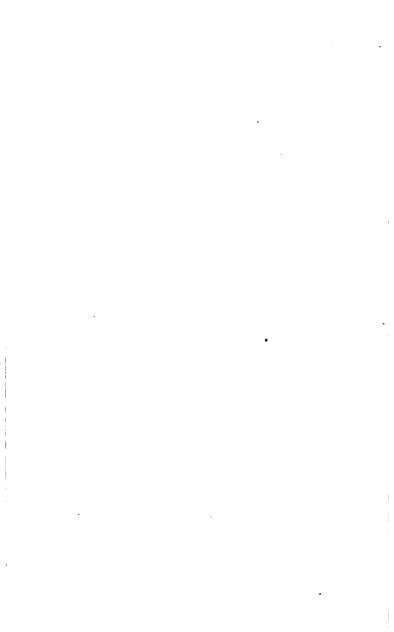


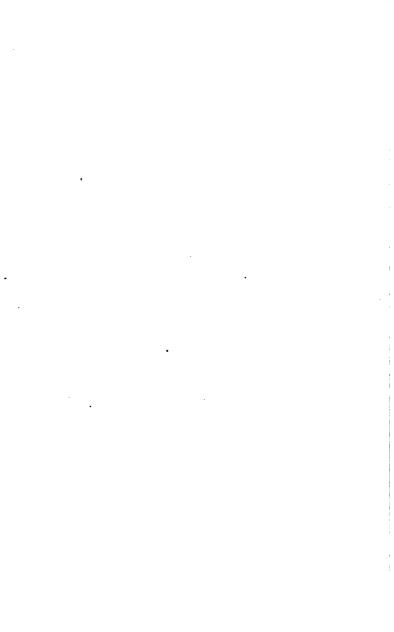




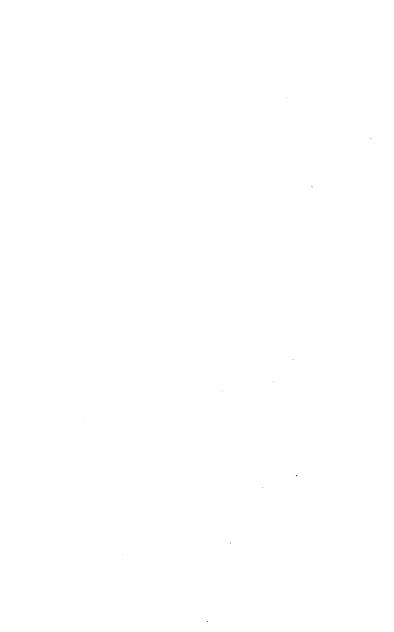


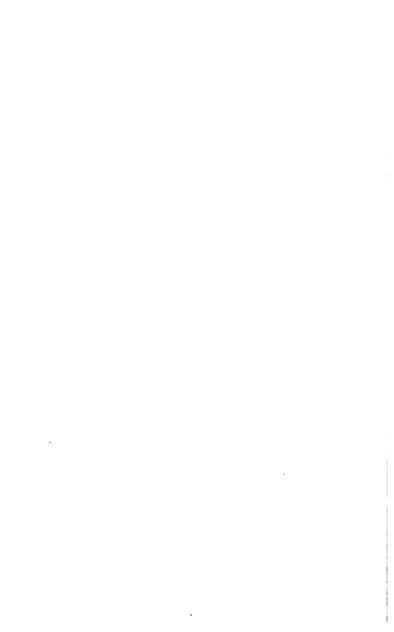


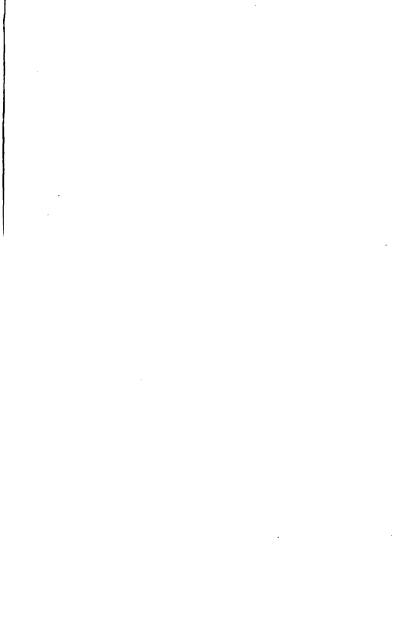


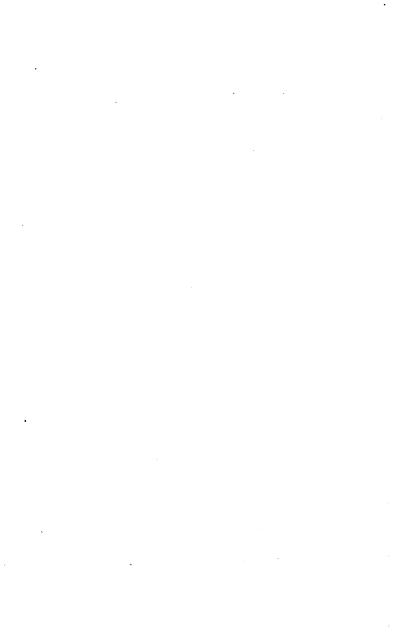




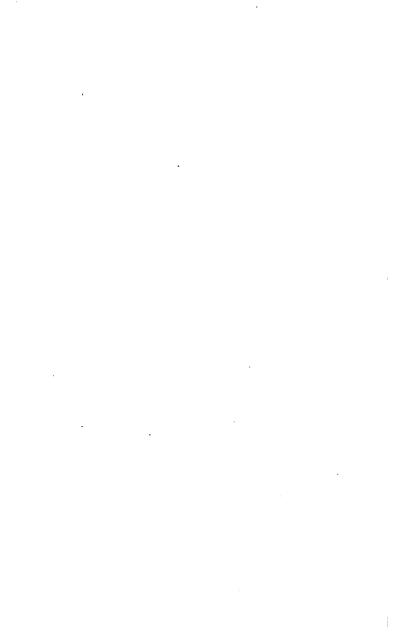


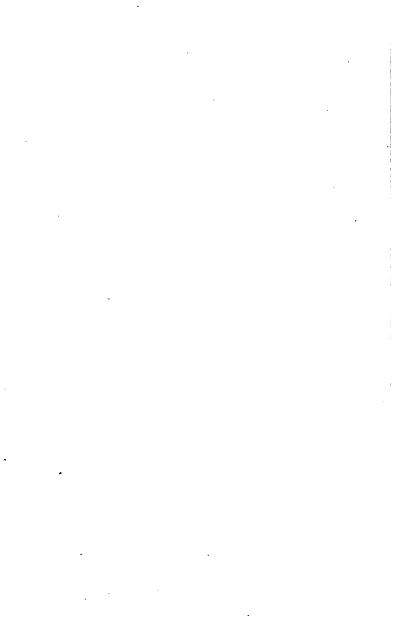






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